May 13, 1963

Aviation Week & Space Technology

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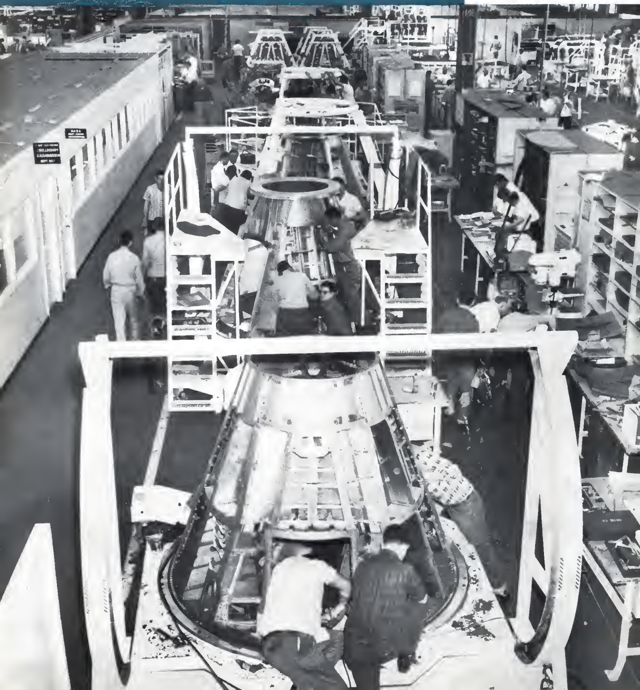
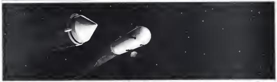
SPECIAL REPORT:

Gemini Design, Manufacturing

Gemini Production Line





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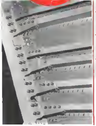

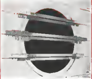

ABOVE. Fiberglass stringers in the antenna area of the Fin Panel are spliced to aluminum stringers. Evenly controlled clamp up of Hi Lok prevents cracking or crazing.

LEFT. Wing rib structure assembled with Hi Loks. High preload fastener is required in critical fatigue stress area.

ABOVE. Minimum tool clearances and return flanges in wing primary structure are easily overcome by Hi Lok 90° and offset installation tooling.

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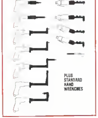

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AEROSPACE CALENDAR

May 20-22—17th Annual Convention and Exhibit, American Society for Quality Control Sherman House, Chicago, Ill
May 20-22—National Symposium on Microwave Theory and Techniques Institute of Electrical and Electronics Engineers Miramar Hotel Santa Monica, Calif
May 20-22—National Telemetering Conference, Hilton Hotel, Albuquerque, N M
May 20-23—Design Engineering Conference American Society of Mechanical Engineers, Americana Hotel New York N Y
May 20-24—Reliability and Maintainability Training Courses Arinc Research Corp Hotel Willard Washington D C
May 20-24—Third European Spaceflight Symposium Stuttgart West Germany Sponsors British Interplanetary Society (BIS) Societe Francaise d Astronautique (SFA) Deutsche Gesellschaft fur Raketentechnik und Raumfahrt e V (DGRR)
May 21-22—1963 Seminar Exhibit, Standards Engineers Society Carnegie International Endowment Center, New York N Y
May 21-23—Spring Joint Computer Conference American Federation of Information Processing Societies, Cobo Hall Detroit, Mich
May 21-23—Symposium Characteristics of the Lunar Surface Boston Mass Sponsors Air Force Cambridge Research Laboratories Arthur D Little, Inc
May 21-24—25th Annual Meeting and News

(Continued on page 7)

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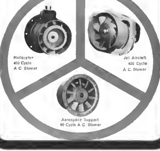

GENERAL DYNAMICS | ELECTRIC BOAT

AEROSPACE CALENDAR

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Conference Aviation/Space Writers Assn , Adolphus Hotel, Dallas, Tex

May 23—Second Annual Management Conference on Marketing in the Defense Industry, American Marketing Assn , Boston College Campus, Boston, Mass

May 27 28—Seventh National Conference on Product Engineering & Production, Institute of Electrical and Electronics Engineers, Continental Hotel, Cambridge Mass

May 27 28—23rd National Meeting Operations Research Society of America Sheraton Hotel, Cleveland Ohio

May 27 29—17th Annual Frequency Control Symposium, Shelburne Hotel Atlantic City, N J Sponsor U S Army Electronics Research & Development Laboratory

June 2 14—Third Annual Reliability Institute University of Connecticut Storrs Conn

June 3-5—Symposium on Materials and Processes for Space Power and Primary Propulsion Society of Aerospace Material and Process Engineers Bellevue-Stratford Hotel Philadelphia Pa

June 3-11—COSPAR Fourth International Space Science Symposium and Sixth Plenary Meeting Warsaw Poland

June 4-6—17th Annual Convention and Exhibition Armed Forces Communications & Electronics Assn , Sheraton Park Hotel, Washington D C

June 4 6—Ninth Annual Radar Symposium, (Secret) conducted by the University of Michigan at Fort Monmouth N J Sponsors USA, USN, USAF

June 4 6—National Electronic Packaging and Production Conference, Coliseum New York N Y

June 6-7—Symposium on the Exploration of Mars Denver Hilton Hotel Denver Colo Sponsor American Astronautical Society Co sponsors American Astronomical Society American Institute of Biological Sciences AIAA Rocky Mountain Sections, NASA

June 7-8—14th National Maintenance & Operations Meeting Reading Aviation Service, Reading Pa

June 7 16—25th French International Air Show Le Bourget, Paris France

June 10-28—Symposium on Lubrication and Wear University of Houston For information Dr D Muster Dept of Mechanical Engineering University of Houston Houston 4 Tex

June 11 14—Symposium on Plasma Space Science, The Catholic University of America Washington D C , with the support of NASA and Goddard Space Flight Center

June 12 14—Heat Transfer and Fluid Mechanics Institute, American Institute of Aeronautics and Astronautics California Institute of Technology Pasadena

June 13 15—Great Lakes Navy Research and Development Clinic Ohio State University Columbus, Ohio conducted by the Office of Naval Materiel

June 17-20—Summer Meeting, American Institute of Aeronautics and Astronautics (AIAA), Hotel Ambassador Los Angeles Calif

June 17-21—Summer General Meeting, In

(Continued on page 9)

AEROSPACE CALENDAR

(Continued from page 7)

stitute of Electrical and Electronics Engineers Toronto Canada

June 18-20—41st Meeting, Aviation Distributors and Manufacturers Assn., Chateau Frontenac, Quebec Canada

June 19-21—Fourth Joint Automatic Control Conference University of Minnesota, Minneapolis, Minn Sponsors American Institute of Chemical Engineers, Institute of Electrical and Electronic Engineers American Society of Mechanical Engineers; Instrument Society of America

June 26-27—10th Annual Symposium on Computers and Data Processing University of Denver's Denver Research Institute Elkhorn Lodge, Estes Park, Colo

June 26-27—Symposium on Dynamic Load Problems—Helicopters and V/STOL Statler Hilton Hotel Buffalo, N Y Sponsors Cornell Aeronautical Laboratory; Army Transportation Corp

June 28-July 3—Second Annual Dorado Fly In Dorado Beach Hotel, Dorado, Puerto Rico

July 7-11—Seventh National Conference on Aerospace Education, National Aerospace Education Council Hotel Deauville, Miami Beach, Fla

July 9-11—International Symposium on Space Telecommunications Institute of Electrical and Electronic Engineers Professional Group on Antennas and Propagation, Boulder Laboratories Boulder Colo

July 10-12—Meteorological Support for Aerospace Testing and Operation American Institute of Aeronautics and Astronautics and American Meteorological Society Fort Collins Colo

July 23-26—Torpedo Propulsion Conference (Confidential) American Institute of Aeronautics and Astronautics U S Naval Underwater Ordnance Laboratory New port, R I

Aug 4-9—International Conference and Exhibit on Aerospace Support Institute of Electrical and Electronics Engineers/American Society of Mechanical Engineers Park Sheraton Hotel Washington

Aug 12-14—Guidance and Control Conference American Institute of Aeronautics and Astronautics Massachusetts Institute of Technology Cambridge Mass

Aug 19-21 — Astrodynamics Conference American Institute of Aeronautics and Astronautics Yale University New Haven

Aug 20-23—1963 Western Electronic Show and Convention (WESCON) Cow Palace San Francisco Calif

Aug 26-28—Simulation for Aerospace Flight Conference American Institute of Aeronautics and Astronautics Deshler Hilton Hotel Columbus Ohio

Aug 26-28—Conference on Physics of Entry into Planetary Atmospheres American Institute of Aeronautics and Astronautics Massachusetts Institute of Technology Cambridge Mass

Sept 22-27—14th International Astronautical Federation Paris France

Sept 23-27 — International Telemetering Conference Savoy Place London England Sponsors Institution of Electrical Engineers (London), American Institute of Aeronautics and Astronautics Institute of Electrical and Electronics Engineers, Instrument Society of America

Aviation Week & Space Technology

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May 13, 1963

SPACE TECHNOLOGY

AIR TRANSPORT

AERONAUTICAL ENGINEERING

MISSILE ENGINEERING

AVIONICS

MANAGEMENT

EDITORIAL

COVER: Four of the five Gemini crew modules on McDonnell Aircraft Corp.'s production line at St. Louis are shown in various stages of fabrication. The crew module, a titanium pressure vessel, is the re-entry portion of the two-man spacecraft and will be mated with an equipment adapter, a retrorocket adapter and a rendezvous and radar module. For a detailed Gemini space vehicle design and manufacturing report and pictures, see p. 52.

PICTURE CREDITS
Cover—Joe Granich, McDonnell Aircraft Corp.; 30, 31, 32—Ben Appelbe; 31—(bot. right) UPI; 36, 83—USAF; 39—Dassault; 52, 53, 54, 55, 62, 66, 81—McDonnell; 85—Martin Co.; 87—Cook Electric Co.; 90, 91, 93—Lockheed; 99—Rolls-Royce; 117, 119—Motorola; 123—Martin.

EDITORIAL

TFX

The investigation by the Senate Permanent Investigations Subcommittee headed by Sen. John McClellan (D-Ark.) into the processes by which Defense Secretary Robert McNamara awarded the TFX contract has reached a point where it is possible to consider the major issues it has raised before the final climactic testimony by Mr. McNamara and his henchmen, Air Force Secretary Eugene Zuckert and Navy Secretary Fred Korth.

We think Sen. McClellan and his group deserve commendation for the objective way they have conducted these hearings, giving all interested parties an opportunity to present their segments of the story.

We also think Sen. McClellan and his subcommittee are performing a valuable public service with their inquiry. We cannot subscribe to Mr. McNamara's view that these hearings could produce "nothing but harm," although we can understand this subjective viewpoint. They have in fact given the American taxpayers a great deal of information, which would otherwise have been cloaked under alleged 'military security,' about how their tax dollars slither around the Pentagon in the weapon system procurement process under the new civilian managers. The inquiry has also provided the first specific and detailed challenge to many of these managers' glib generalizations on the excellence of their own operations. It has required them to support their judgments with valid detail instead of well-polished slogans.

The basic issue raised by the McClellan subcommittee's investigation is whether the weapon system procurement process in the Pentagon is actually being run according to the processes and standards which Mr. McNamara says it is, or whether in fact it is being run quite differently by methods which cannot stand the light of public inquiry.

Key Questions

This contrast between what was supposed to have been done and what actually was done in the TFX procurement process has been shown in several key areas of this process. They are:

- **Cost effectiveness.** Mr. McNamara bases his TFX decision and his entire Pentagon management on the principle of cost-effectiveness. Yet so far there is no evidence, particularly from Mr. McNamara, that he did any cost effectiveness studies of his own after he decided that figures presented by both contractors and USAF were "not realistic," or that he actually has any hard figures to justify any of his statements about TFX costs or his claimed saving of "a billion dollars" by this decision.
- **Technical progress.** Mr. McNamara rejected many of the advances proposed in the TFX technical evaluation process on the grounds that they were unfeasible. Yet the military and civilian experts who have testified to date have documented the technical feasibility of such advances as in-flight thrust reversers, use of titanium, etc. The record shows Mr. McNamara did not consult his own technical advisers in his directorate of research and engineering on any of these issues before making his decision. Where did he get his technical advice?
- **Commonality.** Is this simply another glib generalization or does it have any validity in the TFX case? Mr. McNamara did not invent the concept of commonality. USAF and Navy have used the same aircraft designs many times in the past where technical considerations indicated this was necessary. This concept goes back as far as the Boeing P-12 biplane fighter, which was the first-line fighter for both the Army Air Corps and Navy carrier forces in the 1930s. A recent example is the North American F-86, which served a similar function for both USAF and Navy when it was the best performing fighter of the Korean war era. Is it worth sacrificing the aircraft performance Mr. McNamara's concept of commonality apparently requires for whatever economy is involved? Does he have a valid concept or is it what naval air expert George Spangenberg identified as "poppycock"?
- **Program definition phase.** Is the paper study effort of the program definition phase, which occupied a year during the TFX deliberations, more effective than building several experimental prototypes and wringing them out to get hard test data before full commitment to large-scale weapon system procurement? Is the cost difference between the paper studies of program definition phases and the price of flying prototypes a real savings, or does it prove more expensive in the long run?

Performance vs. Cost

One of the other major issues on which the TFX case hinges is to what degree it is wise to degrade weapon performance to achieve lower cost. Bitter combat experience in all air wars to date has proved that victory cannot be won with second-rate flying machines. In many phases of air warfare the significant margin of performance superiority over the enemy has proved to be remarkably small—perhaps too small for a cost accountant to measure.

As Gen. Carl "Tooey" Spaatz often remarks:

"A second-best airplane is like a second-best poker hand. No damn good."

Since Mr. McNamara overruled all of the future combat users of the TFX in their judgments on aircraft performance and, according to the record, did not consult with any of his military service chiefs in making his decision, it is important for the committee to ask what, if anything, he substituted for their experience.

The final testimony of Mr. McNamara and his service secretaries before Sen. McClellan's subcommittee will be of enormous significance to the citizens of this country and their elected legislators. For upon it will depend in large degree their final verdict as to whether Mr. McNamara is indeed an industrial management genius on whose "rough judgments" the country can depend for its defense, or whether he is just an extremely glib corporate pitchman whose judgments cannot stand the stress of inquiry or the test of time.

—Robert Hotz

WHO'S WHERE

In the Front Office

William E. Robinson and **James J. Kerley**, directors of Trans World Airlines, Inc. Mr. Robinson is the former chairman of Coca-Cola Co.; Mr. Kerley is TWA's vice president-finance. Also: **Norman R. Parmet**, staff vice president-equipment planning and development, Kansas City, Mo.

Continental Air Lines, Inc., has elected the following as directors: **Arnold M. Grant**, New York and Los Angeles attorney; **Donald F. Magarrell**, Denver banker; **Alexander Damm**, Continental's vice president-finance. Also: **Blaine Cooke**, vice president-marketing services, Chicago, Ill.

Dr. Harold Goldberg, vice president-engineering and research, Raytheon Co., Lexington, Mass.

Carl A. Benscoter, executive vice president, Mohawk Airlines, Inc. Also: **John R. Carver**, a senior vice president; **J. C. Brewner**, a senior vice president-finance; **Bruce C. McLean**, a vice president-corporate affairs and secretary.

Abraham L. Cohen, vice president-engineering, Data & Controls Div. of Lear Siegler, Inc., Long Island City, N. Y.

Beverly H. Warren, vice president and general manager, Avco Corp.'s Lycoming Div., Stratford, Conn.

Howard McBurney, a vice president-production and distribution, The Deutsch Co., Los Angeles, Calif.

Richard A. Fitzgerald, vice president-legal and secretary, Frontier Airlines.

Honors and Elections

Dr. Charles I. Barron, a flight surgeon, senior examining physician and medical director of Lockheed Aircraft Corp., has been installed as president of the Aerospace Medical Assn.

Sikorsky Aircraft Div. of United Aircraft Corp. has received the **Igor I. Sikorsky International Trophy**, awarded annually "in recognition of outstanding achievement in the advancement of the helicopter art by the establishment of an official world record." A Sikorsky S-61 helicopter set a world speed record of 210.6 mph. on Feb. 5, 1962, over a 19-km. straight line course. **Lt. Robert W. Crafton** (USN) and **Capt. Louis K. Keck** (USMC), pilot and co-pilot of the record flight, were named winners of the **Frederick L. Feinberg Award**, given each year "to the helicopter pilot who accomplished the outstanding achievement . . . in the preceding calendar year." Named **Honorary Fellows** of the American Helicopter Society: **Michael E. Gluhareff**, former engineering manager of Sikorsky Aircraft, and **Robert A. Stang**, chief engineer, VTOL/STOL Branch, Flight Test Div., Naval Air Test Center, Patuxent River, Md.

Charles G. Gulledge, president of Dynalectron Corp., has been elected president of National AeroSpace Services Assn., succeeding **Rex H. Madeira**, executive vice president of Page Aircraft Maintenance, Inc. **Lewis F. Jeffers**, president of Hayes International Corp., was elected vice president. **Harry S. Baer, Jr.**, was re-elected secretary-treasurer.

(Continued on page 126)

INDUSTRY OBSERVER

► Watch for Air Force to sponsor two parallel studies of an advanced tactical fighter under Advanced Development Objective 12. Design will be aimed at speeds greater than those established for the F-111 (TFX) competition. The new fighters would be intended for service use in the 1970s. USAF Aeronautical Systems Div. will monitor the forthcoming competition.

► **Interception of alien satellites in space will be studied under a group of "phase zero"—pre-program definition—studies planned by Air Force Space Systems Div. Problem areas include basic spacecraft subsystems such as Elint, infrared and nuclear-armament sensors, a target seeker using infrared, radar or lasers, and re-entry vehicles. Sole-source awards may be made to Lockheed for an Agena mission to fly by and photograph alien spacecraft, to McDonnell for a Gemini capsule study, and possibly to Radio Corp. of America.**

► Army is sponsoring a broad research and development effort in re-entry physics under the program name of Black Knight. Aim is to obtain characteristics of ballistic missiles as an aid in development of Army's Nike Zeus and Nike-X anti-ballistic missile systems. The program is being conducted for Army by Stanford Research Institute and is supported by a number of aerospace companies. Some confusion has arisen because the program name is the same as that of a British test vehicle also used in a basic re-entry physics program.

► **Effective use of a lunar-orbiting Apollo spacecraft to perform lunar reconnaissance, help select and possibly prepare future landing sites will be studied in a series of projects planned by National Aeronautics and Space Administration's Manned Spacecraft Center. Basic idea is to make maximum use of an Apollo orbiter before its landing capability and scheduling of actual landing have been achieved. Studies evolved from MSC's original plans for a lunar-reconnaissance module (AW Dec. 24, p. 13) and could lead into a multi-million-dollar hardware subsystem effort.**

► Swiss military plans to buy $10 million worth of Sud Aviation's Alouette 2 and 3 helicopters to fill requirements for small and medium class utility helicopters. Italy's Agusta Bell 204B, Kaman's HH-43B and the Alouette 3 also have completed evaluation in Switzerland for a possible large, high altitude helicopter order.

► **NASA's Mecca Project, test firings in support of nuclear auxiliary power source development, will use mercury fluid in Snap-8 boiler and condenser component configurations in early flights. Firings will be made at NASA's Wallops Island Station at the rate of two or three per year, using small solid-propellant rocket vehicles with up to 1,000-lb. payload capability. Aim of the tests is to determine effects of 8 to 10 min. zero-gravity exposure on liquid-metal boiling and condensing heat transfer.**

► Optical techniques for tracking ballistic missiles during the early launch phase from zero to 60,000 ft. will be studied in a program planned by Air Force's Rome Air Development Center. Velocity and acceleration data must be accurate enough to evaluate short-term changes in booster thrust. Ground-based laser trackers are one possible solution. RADC also will consider a missile-borne optical beacon for triangulation from ground stations.

► **Feasibility of using air augmentation to improve the performance of rocket boosters will be investigated by Martin-Denver. Contract will be awarded soon by Air Force Flight Test Center.**

► Ultraviolet portion of the spectrum appears more promising than the currently used infrared region to determine true vertical by horizon sensing in earth orbital or planetary flights. NASA's Langley Research Center has fired several vertical-probe rockets in Project Scanner to supplement theoretical studies already made. Improved instrument packages, programed for the first quarter of next year, will gather 350 data points per flight in each of several spectral bands with sensors having resolutions approximating 0.03 deg. First flights had instruments with about 3 deg. resolution.

Washington Roundup

Death Knell for RS-70

Next big crisis for Defense Secretary Robert McNamara on Capitol Hill is expected to be the death of the USAF-North American RS-70 program. Defense Dept. decided recently to kill the project outright in spite of the fact that two Congresses have voted money McNamara did not ask for and have tried to force him to expand the effort—now limited to three prototype airframes plus some reconnaissance components for which Defense Dept. has never released the money to Air Force.

But in view of the current troubles with TFX (see p. 27) **and the shakeup of the Joint Chiefs of Staff** (see p. 26), **it was decided that the best course was to let the RS-70 die of financial starvation,** which it is rapidly doing. Although plenty of money is on hand at the Pentagon, it will not be passed along to the Air Force.

Air Force Secretary Eugene Zuckert has been pressing for a clear-cut cancellation since McNamara intends to let the program die, anyway. The first aircraft has run into more technical problems, particularly with its honeycomb structures, and the first flight is now off until next year—a total slip of more than one year. McNamara wrote the House Armed Services Committee on Apr. 24 that he did not believe the $363.7 million just authorized by the House and Senate for RS-70 in unrequested Fiscal 1964 funds would be needed. But he did not indicate his intention to abandon the program altogether.

No other manned strategic bomber project now exists, although a long-endurance aircraft is being studied under Project Maple (AW May 6, p. 33). McNamara has said the present fleet of Boeing B-52s and General Dynamics B-58s will last well into the 1970s, but the B-52 has recently run into new metal fatigue problems that are requiring an extensive modification (see box p. 26). All this coupled with only a one-year reappointment for Chief of Staff Gen. Curtis LeMay—who is "Mr. Manned Bomber" as far as Congress is concerned—promises to give McNamara another painful time on the Hill.

Defense Talent Search

Dr. Harold Brown, director of defense research and engineering, is having trouble recruiting scientists and engineers to fill a number of key posts which have become vacant or will in the near future. A volunteer team of men well acquainted with the specialized fields represented in Brown's office is helping in the talent search. A pattern of coming to the office from industry for only two years and then returning to industry at much higher pay has developed. But the increased centralization of power in the research and engineering office—which creates an atmosphere of increased control over industry—has made the jobs less popular and industry jobs harder to find on leaving.

Decision was to be made late last week on whether two or three program definition phase contracts would be awarded for a military communication satellite. Leading contenders were Radio Corp. of America and two teams—Philco and Space Technology Laboratories, and General Dynamics and Hughes Aircraft.

Support for Apollo

President Kennedy has no intention of abandoning or curtailing the Apollo manned lunar landing program in spite of the current criticism from scientists and politicians. He has had Vice President Lyndon Johnson, the National Aeronautics and Space Council and the National Aeronautics and Space Administration at work gathering arguments to support his views and to answer the critics. NASA submitted a 40-page memo May 4. It is classified secret because it discusses the agency's long-range plans.

Vice Adm. **John S. Thach has been named deputy chief of naval operations for air, replacing Vice Adm. William A. Schoech. Adm. Schoech will replace** Vice Adm. George S. Beardsley, who is retiring, as chief of naval materiel. Rear Adm. John T. Hayward, now commander of Carrier Division Two, has been nominated for temporary vice admiral and assigned as commander of antisubmarine forces in the Pacific.

Senate Preparedness Investigating Subcommittee demanded last week that the "highest priority" be given to a determined project to remove powerful Russian defensive forces from Cuba "at an early date." It also said intelligence officials admit "it is quite possible that offensive weapons remain on the island" even though "to a man the intelligence chiefs stated that it is their opinion that all strategic missiles and bombers have been removed."

Duel-Purpose Aircraft?

The Guardian of Manchester had this to say about the Royal Air Force's order for British Beagle light planes (see p. 35): **"Exhaustive tests have been carried out to adapt** the Beagle to service use. At one point in the testing, the makers demonstrated that it would be possible for a senior officer, no longer slim or young, to enplane in full dress uniform while wearing his sword."

Soundings taken by top Air Force planners as their ambitious review of the service's technical and organizational future gets under way have already led some of them to switch from the official name—Project Forecast—to the unofficial title of Project Overcast.

—Washington Staff

McNamara-Anderson Rifts Led to Ouster

Navy chief dropped after one term due to clashes over TFX testimony, Cuban crisis, reorganization.

Washington—Admiral George W. Anderson was not reappointed as chief of naval operations because he capped a series of disagreements with Defense Secretary Robert S. McNamara by refusing him a copy of testimony he was going to give to the Senate Subcommittee investigating the F-111 (TFX) contract award.

President Kennedy said last week that Adm. Anderson has agreed to "serve the United States in a position of high responsibility," but said no announcement of what the job is will be made until this summer. The plan to drop Adm. Anderson when his first two-year term expires Aug. 1 was revealed in a White House announcement May 6.

Adm. David L. McDonald, commander of U. S. Naval Forces Europe, will succeed Adm. Anderson. Adm. McDonald has been in his current post only one month.

The defense laws of 1949 and 1958 give the secretary of defense power to see any document in the department. But Adm. Anderson refused to send the secretary an advance copy of the testimony he gave in the TFX investigation, which was among the most critical of McNamara's decisions that any witness has given (AW Apr. 15, p. 28).

The same White House announcement said Gen. Curtis E. LeMay, Air Force chief of staff, would have his two-year term extended for one year beyond July 1. As late as two months ago, Air Force Secretary Eugene Zuckert was against reappointment of Gen. LeMay.

The change in attitude came about because Gen. LeMay's F-111 testimony was considered factual but far less openly opposed to McNamara's position than Adm. Anderson's, even though Gen. LeMay initially had disagreed with civilian authorities over the choice of contractor.

For more than a year after he took office on Aug. 1, 1961, Adm. Anderson adhered strictly to McNamara policies. He passed the word among Navy officers in the Pentagon that McNamara's policy was Navy policy and that any officer who stepped out of line would be disciplined or transferred.

When the TFX competition was extended to a fourth round of proposals late last June, Adm. Anderson objected strongly in writing and in person.

About the same time there was a change in Navy secretaries. John Connally, the Kennedy Administration's first secretary, had backed Adm. Anderson strongly in the F-111 case and in other matters. Connally left to run successfully for governor of Texas and his replacement, Fred Korth, Ft. Worth, Tex., tended to side with McNamara.

Last summer, studies were begun on reorganization of Navy's procurement machinery to bring it more into line with those recently implemented by the Air Force and Army. John Dillon, chairman of the reorganization board, recommended creation of a Chief of Naval Support who would rule over the procurement bureau. He would report directly to the Navy secretary but would have only a liaison relationship with the chief of naval operations.

Adm. Anderson objected strongly to this proposal because it gives the chief of naval operations even less authority than he has now under the bi-lineal system, in which the bureaus report to the secretary and the operational forces and requirements elements report to the chief. He also opposed keeping what he considers a top-heavy civilian echelon under the secretary which monitors the bureaus. Dillon is at the top of this group as administrative assistant to the secretary.

Korth supported Dillon, and the study received favorable consideration in McNamara's office. As of late last week no action on the plan had been announced.

When the Cuban crisis broke last October, a series of events occurred which Adm. Anderson considered ignored the normal chain of command. The first happened Oct. 6 when Deputy Defense Secretary Roswell Gilpatric bypassed the Joint Chiefs of Staff, the chief of naval operations and the Air Force chief of staff by calling directly to Adm. Robert L. Dennison, commander-in-chief, Atlantic, at the headquarters in Norfolk and ordering him to send a Navy F4B fighter squadron to Key West, Fla. from Oceana, Va., where they would be placed under Air Force control (AW Oct. 15, p. 26).

Adm. Anderson's feelings about this action were well known within the Navy at the time and were shared by the great majority of Navy officers in the Pentagon.

As the crisis deepened Adm. Anderson began round-the-clock watches in the Navy's top secret Flag Plot (operations center) located in a Marine-guarded restricted area in the Pentagon's D ring between the fifth and sixth corridors.

When Navy ships and aircraft began intercepting Cuba-bound vessels, McNamara began spending many hours a day in Flag Plot. He insisted on making decisions on the spot. He also wanted to call ship's commanding officers directly on the voice scrambler single-sideband radio circuits.

Any command and control center uses complex operations procedures down the whole chain of command and uses stylized voice communication, including code names. McNamara was not acquainted with these. Adm. Anderson tried to prevent McNamara from using these non-standard procedures in several instances that were observed by the many officers and enlisted men who were on duty in Flag Plot.

Adm. Anderson put his ideas on military relationships into a speech before the Navy League on May 3 at San Juan, P. R. "Without respect flowing both ways between juniors and seniors," he said, "we have little hope of doing the jobs we will be called upon to do."

He then made a distinction between "command" and "order." "Our concept of the meaning of command is that it is a direction which must be executed immediately, precisely and without equivocation. . . . Commands permit no deviation," he said. "Orders, on the other hand, are issued in such a way as to tell a man what to do, but not how to do it. Each man is expected and required to exercise his own initiative and responsibility so that the orders are carried out."

Defense officials felt that at times Adm. Anderson had "upstaged" them and treated them with condescension.

By way of contrast, they say that they have been surprised at Gen. LeMay, who for many years has had a reputation for bluntness. He has fallen into line in his personal relations with civilian officials and has gone along with ideas of the other members of the Joint Chiefs of Staff in many instances where in the past he would have objected.

But the most outstanding result of his tenure since July 1, 1961, and his previous tenure as vice chief of staff, according to defense officials, has been quick reorganization of the Air Force to streamline its procurement structure and the more recent reorganization of the Air Staff to conform to the organization of the office of the secretary of defense.

Officially, the explanation for extending Gen. LeMay's term was that he offered wartime combat experience as a general officer and that it was desirable to stagger the terms of the service chiefs. Actually, it will mean that the terms of three of the four chiefs will expire within three months of one another in 1964. The official explanation in Adm. Anderson's case was that tours for the naval chief have been two years except for Adm. Arleigh Burke and the department wished to return to this pattern. In fact, Adm. Louis Denfeld was appointed to a second term but was fired by President Truman in the "revolt of the admirals" shortly after he began the second two years.

B-52 Retrofit

Estimated $100 million modification and retrofit program to strengthen a section of the rear fuselage, just forward of vertical stabilizer, of the Air Force's B-52 fleet is expected to be implemented sometime this year.

Boeing and the Air Force now are developing and testing the retrofit package. Retrofit of more than 700 B-52s in the Air Force fleet is expected to be costliest modification program in Air Force history.

Modification program is being instituted as a result of three B-52 accidents—one in January, 1961 and two in January, 1963.

All three planes eventually crashed after control was lost. Cause has been traced to structural fatigue resulting in failure of the section of the aft fuselage. Turbulent air probably triggered the failures.

F-111 Subcontracts

Two new subcontracts for F-111 (TFX) systems have been awarded by General Dynamics/Ft. Worth to Avco Corp. and Eclipse-Pioneer Div. of Bendix Corp. Awards bring the total of subcontracts awarded by the prime contractor to more than $22 million.

Avco's Electronics and Ordnance Div. at Cincinnati received a $4.2 million contract for development of countermeasures receiving systems.

Eclipse-Pioneer, located at Teterboro, N. J., received a contract valued at approximately $990,000 for an air data computer system.

In addition, Hughes Aircraft Co. has chosen Rocketdyne's Solid Propellant Operations Div., McGregor, Tex. to provide the solid propellant propulsion system for the Phoenix air-to-air missile to be used on the Navy's F-111B (AW Apr. 1, p. 23).

The contract, estimated to be worth approximately $3 million, is awaiting Navy approval.

General Dynamics Rejects Plan For TFX Flying Prototype Contest

By George C. Wilson

Washington—General Dynamics-Grumman last week opposed flying its F-111 (TFX) tactical fighter prototype against Boeing's as suggested by Sen. John L. McClellan (D.-Ark.) on grounds the competition would be both unfair and unrealistic.

Roger Lewis, General Dynamics Corp. president, told the Senate Permanent Investigations Subcommittee that "to interfere with the momentum of the existing program would be wasteful of the work already accomplished and would delay significantly the operational date for the TFX." He said General Dynamics won the contract after an exhaustive competition and has already started work entailing commitments to subcontractors.

Lewis said that a contest between prototypes would not be too meaningful. "I do believe the question here is one of the value of the total weapon system, which is the airplane, the fire control, the engine, the whole weapon system, which can only be determined by the construction of the complete system and the thorough testing of that system.

"The military people who laid this program out determined that this would require about 23 airplanes to test this weapon system for both users," Lewis said. "It is our feeling that two or four airplanes, while they would certainly show that both airplanes flew—I think the flying part is relatively simple—would not demonstrate in our judgment the worth of either system as a weapon system. It simply isn't enough testing for that purpose." He declined to estimate how much it would cost General Dynamics to build two prototypes of the tactical fighter.

Another disadvantage of a flying competition of prototypes, Lewis said, is that the time consumed may leave all the competitors "at the post by technological advances which have taken place in the meantime and perhaps by the enemy's advances. . . . What is really at issue in this decision, or was at issue in this decision, was the worth of the final article as a fighting machine, and this you would not find from simply flying two bare airframes."

Sen. McClellan, chairman of the investigating subcommittee, suggested the flying competition of prototypes and was buttressed by a Rand Corp. study which said the approach may well be the best way to choose the best airplane (AW Apr. 22, p. 31).

"The big issue here," Sen. McClellan said May 2, "The thing that weighs heavily and predominates in this inquiry here is: are we getting the best, because the best may not be more than just good enough when the real test comes. . . . I don't care anything about Mr. Boeing or Mr. Dynamics. They don't mean anything to me. We are dealing here with the destiny of our country. That is all important." He said extra money spent to build prototypes for testing "to make certain that we are taking the best plane would not be money thrown away."

His comments came after William M. Allen, Boeing president, told the subcommittee his company could build two flying prototypes for $105 million (AW May 6, p. 24). One would be an Air Force and the other a Navy version. Allen said Boeing favors a flying competition over cancelling the existing F-111 contract with General Dynamics-Grumman "because it would permit a direct comparison and evaluation of actual aircraft built by the two competitors."

Defense Secretary Robert S. McNamara awarded the F-111 contract to General Dynamics-Grumman even though the Boeing bid was $415.5 million lower and was recommended by USAF-Navy source selection board four times. The contract is expected to total $6.5 billion for developing and building 1,700 aircraft.

Even if a majority of the subcommittee voted formally for a flying competition, it is virtually certain McNamara would reject it since he said as recently as May 1 that his F-111 decision has been strengthened by such information as the General Accounting Office's criticism of Air Force cost calculations.

During the next few weeks, McNamara and the Air Force and Navy secretaries will be called before the subcommittee to support their F-111 conclusions that have been so severely challenged since the inquiry started Feb. 26. The points at issue come under the general headings of cost realism, commonality and technical feasibility. In addition, they will be asked about such policy matters as the damage done to the competitive spirit of the aerospace industry by stretching competitions like the F-111 over such long periods that the designs become similar to the disadvantage of the superior one.

The service secretaries will try to counter the following testimony by Boeing officials and others against their F-111 judgment:

• **Cost realism.** Boeing officials testified

at length in refuting Air Force Secretary Eugene M Zuckert's Nov. 21 memorandum, which was signed also by Navy Secretary Fred Korth and McNamara

The memo said "It is hard to understand the optimism of the Boeing estimates for engineering, tooling and manufacturing With respect to tooling costs, it appears from the estimates and the rationale used by Boeing that they are approaching the development of this aircraft on a very simple basis Boeing has reduced its man-hour estimates for manufacturing by as much as 30% below the industry average and has based much of its estimating on experience with B-52, KC 135, B 47 and Bomarc costs It is not believed that this experience is directly applicable to a high-density, complex fighter aircraft Boeing provided for acquisition of duplicate tooling in the production, which reduces the RDT&E cost estimate Sustaining tooling man-hours have been reduced to a most unrealistic level and sustaining engineering has again, through bookkeeping, been costed in the production program rather than in the RDT&E program This implies that there would be no manufacturing difficulties due to engineering change proposals during the research and development program We conclude that the Boeing formula for estimating the cost of the aircraft resulted from an over-optimistic impression of the complexity of the TFX in relation to Boeing-produced bombers Boeing's estimates for the total research and development program are so low that in our opinion, they have seriously misjudged the difficulties to be expected in this aircraft of new concept "

Boeing Work

Allen said that because Boeing had worked on a F-111 design before proposals were requested, "we were extremely well prepared to make a realistic and highly competitive price proposal ... With full recognition of the risks involved we made a proposal in good faith with the objective of giving the government a better weapon system for its dollar It is most disillusioning and discouraging to discover that one of the principal reasons Boeing lost the award was because our fixed-price bid was considered to be too low "

Edward C Wells, Boeing vice president and general manager, said "our confidence in our cost estimates is most clearly demonstrated by our proposal to fully develop, test and demonstrate the TFX weapon system for a fixed price with a maximum cost ceiling to the government, and we guaranteed to pay any additional costs out of our own corporate funds ... On the basis of our record on this type of contract, we cannot accept the assertion that we would have either incurred excessive losses on this program or that we would have proposed change orders to cover any unanticipated costs Clearly we would have been obligated to complete the program defined within the price quoted "

GD Defends Design

Washington—General Dynamics-Grumman F-111 (TFX) will give the U S "more combat effectiveness per dollar" than the proposed Boeing aircraft and is definitely superior in the basic mission of penetrating defenses at supersonic speeds, Frank W Davis, president of General Dynamics' Ft Worth Div, said in testimony released late last week

Davis told Senate investigators his company's F-111 has the better supersonic dash capability because its frontal area is designed smaller to minimize drag "The larger frontal area of the Boeing design would require basic and fundamental redesign to improve," Davis said He said thrust reversers could not be developed in time to meet Air Force schedules but will be installed "if and when" a satisfactory one is developed

Allen said the service secretaries never sought detailed information explaining the basis for Boeing's cost estimates Because USAF Col Charles A Gayle, F 111 program director at Wright Patterson AFB felt during the competition that Boeing's cost estimates were too low, Charles Keeton, Jr, Boeing finance manager said the firm reviewed all its figures and concluded "our estimates had been realistic and supportable all along" He said the estimates were part of the effort of a special Boeing F-111 team numbering more than 1,000 persons "We, in fact, have more detail and backup information on the TFX proposal than we have ever had on any proposal that has ever been submitted before by the Boeing Co " Sen McClellan decried the fact that Defense Dept officials rejected the low bid without exploring the basis for the cost estimates

Sen McClellan Were they [the Boeing cost figures] ever really challenged until they got to the secretary level and then arbitrarily just thrown out?

Wells No, sir

Sen McClellan Have they ever called you in and said "Your price is too low ... show us here how you arrived at such figures?"

Allen No, sir

Sen McClellan Well, I think it would be in the interest of the government and in the interest of the taxpayers of this country to get this low bid That is what competition is for, is it not ... for the purposes of economy and also to get the best product?

Allen That is my understanding of the concept

Sen McClellan. That is my thought about it ... On a bid of this size, on a contract of this magnitude, I cannot understand why you would arbitrarily, even if they thought your bid was too low, just arbitrarily throw it aside and not bring you in and give you an opportunity to substantiate your figures, and point out to them why you were able to do it at that price, and you needn't worry about your not being able to carry out the contract It seems to me that that is what would have been done "

In regard to Boeing's man hour estimates for manufacturing being 30% below the industry average, the subcommittee's accountant said this apparently was an Air Force misinterpretation quoted by Zuckert Thomas E Nunnally, the staff accountant said that in its proposal Boeing had noted that its man-hour experience in producing bombers was 30% below the industry average "but they did not say that their proposal for the TFX was 30% below the industry average."

High-Density Aircraft

As for lack of experience in building high-density aircraft as opposed to bombers, Allen said "I assume that all would agree that our extensive experience in building the supersonic Bomarc pilotless aircraft which operates at Mach numbers higher than the TFX would be applicable to TFX estimating This air-breathing vehicle is comparable in size to the F 104 fighter aircraft, with a length exceeding 45 ft and a weight over 15,000 lb It is tightly packed with propulsion units, guidance and other electronic equipment, and is an extremely dense and complicated article "

• **Commonality** Boeing witnesses also took sharp issue with the part of Zuckert's memorandum that said General Dynamics "has a distinct edge" in the degree of commonness, or commonality, between the Air Force and Navy versions of the F-111 He said 85% of the parts in the General Dynamics design were identical compared with 60% for Boeing (AW Apr 8, p 28)

"No amount of peripheral argument," Wells said, "should obscure the fact that these were Boeing's proposals

"**A single airplane**, not two with Air Force and Navy versions dimensionally identical in all major particulars, including wings, control surfaces and wing sweep angles

"**To produce all airplanes** on a single production line and on basically identical tooling

"**The use of fully modern** tooling and production techniques which would result in substantially superior weapon system performance compatible with separate Air Force and Navy missions, while fully protecting inherent savings of a joint program "

Wells said the purpose of commonality, as he understood it, "was to reduce total over-all cost" His firm did thus, he said, but still lost the contract "The evaluator who chooses to use it [commonality] as an index of merit in itself is led to ignore the fact that in meeting two different mission requirements, a high index of commonness may well result in higher than necessary cost as well as lower than available performance, Wells said "In the case of the TFX, therefore, we considered commonness as a means to an end rather than an end in itself."

Sen McClellan, after noting that only about 200 of the 1,700 F-111s were going to the Navy, said "I think the public ought to know that this thing of commonality is applicable only to less than one-sixth of the planes, or only about 200 They are making a great big noise about commonality, and that is what it amounts to." He said since each F-111 is expected to be developed and produced for about $3.4 million, the whole Navy order of 200-plus aircraft would cost about $800 million So how, he asked, can McNamara claim a saving of $1 billion through the alleged greater commonality of the General Dynamics design?

"This is the kind of propaganda being thrown out all over the country to try to sustain this 'rough judgment' decision that has been made involving the security of our country and its safety ... If that is an illustration of the accuracy of the rest of this, then the whole thing ought to be reviewed from top to bottom," McClellan said

• **Technical feasibility** Wells' testimony included point-by-point refutations of what Zuckert's memorandum said were additional examples of "excessive optimism" in the Boeing proposal The memo said these included "the apparent belief that thrust reversers can be developed without major problems and engineering changes the view that the variable sweep wing can be quite easily applied to the TFX concept, the use of titanium in structural members, and the unique design for the propulsion installation These examples suggest, if our experience is any guide, that much redesign and testing would be necessary, contrary to the reduced engineering estimates and cost indicated in the Boeing proposal " Zuckert said further that General Dynamics' design had superiority in such areas as propulsion, flight control and aerospace ground equipment which outweighed deficiencies in offensive systems reconnaissance and penetration aids

• **Thrust Reversers** "The high versatility and superior performance offered by this device is completely practical and feasible for the TFX," Wells said "The thrust reverser is the only deceleration device which can work effectively over the entire speed range of the TFX airplane from zero to the maximum design requirement ... It appears probable that any aircraft operational in the 1970 time period which does not incorporate such a device will be considered obsolete or definitely second rate The Boeing Co has over 10 years experience with this type of device and has at this time more aircraft flying with its own thrust reverser design than all other companies in the world put together " He said the thrust reversers are not used regularly in flight on existing aircraft but have been demonstrated He predicted that Russian aircraft by 1970 will have in-flight thrust reversers The Boeing 727 short-range transport uses thrust reversers "essentially identical" to the ones proposed for the F 111 and has proved "completely satisfactory," Wells said He said the type of top-mounted inlets employed on the F-111 design has proved satisfactory during actual use on the 727 Wells added that Boeing in an Oct 19 progress report to USAF F-111 project officers supplied test data which showed the feasibility of the top mounted inlet "through the complete design angle of attack limits for the TFX airplane"

• **Variable sweep wing** "Over 1 million man-hours of engineering effort have been spent in exploring the critical technical features associated with variable sweep," Wells said, "including, for example, 5,000 hr of wind tunnel tests—essentially the same amount of wind tunnel testing" that was accomplished on the B-52 at the time of its first flight

• **Titanium** Wells said the planned use of 6-aluminum-4 vanadium titanium alloy in the wing center section carry-through structure "is probably more conservative than the use of titanium in the engine—30% of the material by weight in the engine is titanium " He said Boeing never intended using titanium in the heavily loaded wing pivot bearing but would have used a steel insert with Teflon-impregnated Fabroid bonded on the steel for the actual wearing surface

In answer to the General Dynamics F-111 advantages cited by Zuckert, Wells said "I would presume that the purpose of developing a weapons systems is to carry offensive systems, reconnaissance and penetration aids, and I can't quite imagine how these other factors can possibly outweigh deficiencies in the areas stated to be deficient here "

DOD Plans New Selection Policy

Washington—Defense Dept is completing a new "source selection" policy for its major advanced-technology procurements—such as the controversial F 111 (TFX) tactical fighter

It will make a "distinct separation" between the evaluation and selection process, with final selection authority resting with the secretary of defense

Deputy Secretary of Defense Roswell Gilpatric said last week that issuance and implementation of the new policy is being withheld indefinitely, because "in the present atmosphere it would be construed as a result of the McClellan hearings This is not true It has been under way for a long time "

Gilpatric described the new policy as "an extension and perfection of the present procedure" for evaluating and selecting the sole contractor for a major new weapon procurement He specified that it would not downgrade the present weight given to military boards in the evaluation process

General Dynamics Corp would still have been selected over Boeing Co for the multi-billion-dollar F-111 project (see p 27) under the new policy, Gilpatric said "But there would have been less fall-out and repercussion "

The subcommittee of the 21-member Defense Industry Advisory Council that participated, in an advisory capacity, in the drafting of the new source selection policy was appointed last October It consisted of William M Allen, president of Boeing, Thomas V Jones, president, Northrop Corp, and Charles B Thornton, board chairman, Litton Industries, Inc John H Rubel, deputy director of defense research and engineering, served as chairman of the subcommittee

Defense Secretary Robert S McNamara will take over chairmanship of the council from Gilpatric when Gilpatric leaves his government post this summer

Action will be taken shortly by Defense Dept in five other areas considered by the council at its third meeting on May 3 and 4, Gilpatric reported These are

• **Classified briefings** of industry on future research and development plans will be brought under closer coordination by the secretary of defense

• **New rules will be issued** relaxing management controls under incentive type contracts

• **Regulations establishing** a system of "weighted guidelines" for profits or fees on non-competitive negotiated contracts will be issued They will be based on a study by Logistics Management Institute last fall

• **Defense Dept's** long standing policy of banning systems engineering contractors from entering into competitions for production will be written out

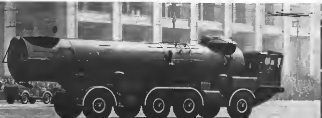
• **Record of contractor performance** will be established, probably in early July (AW Apr 15, p 32)

Two submarine-based ballistic missiles (top photo on both pages), code-named Snark by NATO, are hauled through Red Square during Russian May Day parade (AW May 6, p. 36). Missile is probably two-stage, solid propellant type. Cluster at base may be driving plug for underwater ejection from launching tube, manifolded cluster could contain propellants for gas generation in tube, avoiding compressed air ejection system. Missile is approximately 40 ft. long from top of driving plug to rounded nose cone.

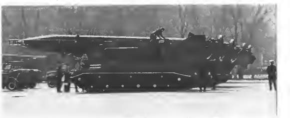
Soviets Parade Missile Inventory; Refinements Are Evident in New Ground Handling Equipment

Two types of anti-aircraft missiles (above)—SA-2 Guideline (left) and SA-3 with black nozzle covers—show basic differences. Guideline has estimated slant range of 30 mi. and altitude coverage to about 80,000 ft. SA-2, one of several types of Russian missiles emplaced in Cuba, shot down a USAF U-2 during last autumn's Cuban crisis. It uses a booster for launching. SA-3 is designed primarily for defense against low level aircraft. Newest of equipment shown was the missile transporter (below) which also may serve as a launcher. Forward dome of transporter was open, with its cover plate stowed on top, only a small portion of the missile nose showed.

Wire-guided anti-tank missiles (above), first shown during the 1962 May Day parade, have been designated Snapper by NATO. It also was deployed in Cuba. Missiles are mounted three to a vehicle, in this case probably an amphibious scout car. Estimated range is one mile, visual guidance is aided by flares mounted at base. Frog short-range battle field missile (lower right), another type deployed in Cuba uses a solid propellant rocket engine with a cluster of six nozzles. With a center nozzle the pattern would be much like the Snark tube section (above). Six fins provide additional aerodynamic stability in reduced diameter; fin and nozzle combine to increase accuracy.



Sandal (above left) and the earlier Shyster (above right) are ballistic missiles linear descendants of the wartime German V 2 Sandal has a flared skirt and smaller fins. Nozzles have been plugged with standard weather covers to keep out contaminants before launching. Sandal was the medium range ballistic missile whose deployment in Cuba touched off the crisis last fall.



Shaddock, a battlefield rocket (above) is about 35 ft long and has estimated range of 50 mi Transporter-launcher has two control cabs, with driver sitting on left and missile control chief sitting in the right hand cab

Soviet SA-3 anti-aircraft missile uses canard layout, with main wings carrying control surfaces for maneuvering. Controls are in one plane only, indicating that the missile banks to turn like a conventional airplane rather than using control surfaces on both vertical and horizontal lifting surfaces Trunnion to right of Red Air Force crewman probably mates with support structure at fixed-base site.

USAF, Army Fight Caribbean Communists

By Larry Booda

Washington—Air Force Air Commandos and Army Special Forces are employing a wide variety of aircraft in at least eight Latin American countries in an accelerated effort to help those nations counter communist influence and suppress communist-supported insurrection.

The unpublicized U S effort to neutralize communist activities directed largely from Cuba is based in the Canal Zone, and depends almost entirely for logistic and combat support on relatively low-performance, obsolescent aircraft which are ideally suited to jungle operations Most of these aircraft belong to USAF, a few to the Army

USAF and Army personnel, wearing identical green uniforms, are fanning out into Central and South America from their Canal Zone home bases at the invitation—open or covert—of the countries that want help. The type of aid ranges from active participation in propaganda and military actions to training local forces to perform those missions Central Intelligence Agency is also operating in these countries

Countries Involved

These are the countries in which the Air Commandos and Special Forces have operated or are operating now under Army Lt Gen Andrew P O'Meara, commander-in-chief, Caribbean

- **Venezuela** Communist infiltration is an accomplished fact here and open insurrection is under way More than 3,000 Special Forces and Air Commandos are training local forces and providing equipment and supplies
- **Colombia** Little or no communist infiltration has occurred in this country However, a serious internecine warfare has been going on here since 1948 at the cost of an estimated 300,000 lives The conflict could be described as a civil war between government and non-government supporters, or between the haves and the have-nots U S forces are helping in a propaganda effort, and have furnished three Kaman HH 43B Huskie helicopters with mounted machine guns to soften anti-government strong points for government troops (AW May 6, p 27) The three aircraft were modified at the Kaman plant at Bloomfield, Conn., not the Combat Applications Group at Eglin AFB, Fla. as reported last week Each has a 30 cal machine gun mounted on the right side near the deck line where the feed belt can be reached by the occupant of the right seat A tubular flame hider protects the occupant
- **Ecuador and Peru.** The U S effort here is mainly in training local forces in methods to overcome communist infiltration
- **El Salvador, Honduras and Nicaragua** The U S effort in these countries is similar to that in Ecuador and Peru
- **Guatemala** Help here has been limited to furnishing of Army training and equipment

Panama is the field training area for Air Commandos and Special Forces The Panamanian government has taken advantage of their presence to provide medical assistance to its people who live in virtually inaccessible areas

Detachment 3 of the Air Commandos located at Albrook AFB, Canal Zone, is tripling its forces to a total of 500 men and 50 aircraft to meet the increased demand for its services The activities of Detachment 3 in Panama illustrate the type of activity they can conduct elsewhere

The basic aircraft for jungle penetration is the Helio U-10 a short-takeoff-and-landing aircraft which can operate in 500 ft or less over 50-ft obstacles

In a typical action a U 10 will fly over a village and drop instructions to the natives to cut a landing strip through the trees If the natives do not have enough equipment one or more parachutists will descend with power chain saws and other tools If more help is needed a C 47 is summoned to drop more parachutists or equipment

After the strip is built a U-10 carrying a Panamanian doctor or an Air Force medical man is flown in to inoculate the natives with universal shots for the most prevalent local diseases This type of operation was conducted at the San Blas Islands off the Caribbean coast of Panama At one place 300 injections were given

Other types of missions include dropping propaganda leaflets and broadcasting propaganda from the air

Two areas in Panama are used to practice landings involved in counter insurgency missions—Guanico Abajo and Guanico Arriba These sites have been used mainly for light parachute jump and cargo drop practice

Natives with machetes can usually hack landing strips from areas of tall grass or small trees A strip 750 to 1,000 ft long is usually required, but if conditions do not permit clearing such a long strip it can be 500 ft or less, depending on obstructions at the ends of the strip The U-10, making a full-performance landing can land and stop in 175 ft., but more is required for a safe takeoff

Helicopter Operation

In some instances where local help is not available in a heavy jungle area, a helicopter—possibly an HH-43B or HH-21 lowers a man with a chain saw into the trees He clears a helicopter landing area, using parts of tree trunks for a corduroy landing mat if necessary, and the helicopter then lands with a crew to clear a landing strip

Douglas B-26 and North American T 28 aircraft are used to hit targets with machine guns napalm 2 75 in rockets and 100 lb bombs Most South American countries have air force pilots who can be easily trained to operate these aircraft

Some of the missions being flown with the U 10 are extremely long range One version of that aircraft has a range of more than 1,400 naut mi At an economical cruising speed of 100 kt the flights last 12 hr or more Pilot fatigue is a problem faced by the operating groups CIA also operates U 10s in the Caribbean area

Air Force and Army operations in Panama are conducted with no attempt at secrecy Activities in other countries are made without announcement, however

30-Day Manned Balloon Flights Planned

Washington—Series of manned balloon flights lasting as long as 30 days is being planned by Navy and the National Aeronautics and Space Administration under a joint agreement now being completed Plan is to launch three or more crewmen to altitudes up to 100,000 ft to conduct long-duration psycho physiological and system studies on which to base requirements for equipment in future aerospace vehicles

The project will call for a new gondola, which will house a sealed cabin The balloon will be in the 100-million cubic ft class and will be powered to avoid drifting long distances

First flights will probably be scheduled for next summer because optimum balloon flight weather comes between May and September Initial flights will last a few days, and will increase gradually to 30-day flights by mid-1965

Among systems to be tested are high-altitude aircraft escape devices and extra-vehicular space suits It is expected that crewmen for the flights, who have not been selected yet, will represent a cross-section of ages and physical conditions

NASA Weighs 72-hr. Mission After MA-9

By Edward H. Kolcum

Washington—U S is considering a 48-orbit, 72-hr manned Mercury mission in September but will not make a final decision until Maj Gordon Cooper's 22-orbit Mercury Atlas-9 flight has been analyzed and the operational, funding and political implications of an added mission are assessed

Maj Cooper is scheduled to be launched in his Faith 7 capsule between 9 and 11:30 a m (EDT) May 14 from Cape Canaveral Fla His orbit will be at an altitude of 100 to 170 mi and he is scheduled to land about 34 hr after liftoff in the Pacific, 80 mi southeast of Midway Island

MA 9 is designed to wring the maximum flight time from the basic Mercury configuration, and is still considered to be the final Mercury flight However recently-confirmed delays in the Gemini program (AW May 6, p 22) have complicated what would have been a straightforward decision to schedule MA-10 only if MA 9 does not go according to plan

National Aeronautics and Space Administration's dilemma is in balancing the gain against the expense risk and manpower demands of MA-10 Within the agency, the operational side strongly favors another mission as the only means of keeping its ground and flight crews in a reasonable state of readiness Their point is that without an MA-10 flight there will be an interval of at least 17 months—May, 1963, until October, 1964—between MA 9 and the first manned Gemini flight and the crews are likely to become stale in this time

The argument against the flight centers on funding Although NASA already has spent $560,000 on MA-10 mission studies and long lead-time hardware items the agency still officially considers MA 10 solely as a backup to MA 9 The full MA-10 mission will cost an additional $8-$10 million which NASA does not have If MA-10 is flown, the money to pay for it would have to come from a reprogramming action—probably from Gemini funds

What would make this difficult is the irritation Congress already has expressed over NASA's reprogramming (AW Feb 18, p 38), and the fact that an MA-10 flight in September would still leave a 13-month gap between manned flights

While at this point NASA says MA-10 is a backup and the general feeling among decision-makers is that given a good MA 9, there will be no MA-10, the agency has not completely ruled out another flight, even if Cooper's mission is perfect The agency must weigh a number of other factors caused by the Gemini delay These factors include

• **Congressional and public** support for the manned space flight program, which is budgeted at $3 8 billion in Fiscal 1964 but without a manned flight to demonstrate a return on the money during the fiscal year

• **Probable Soviet** manned space spectaculars (AW Apr 15, p 38) There is a feeling among U S experts that Russia already is overdue for an attempt at an 8-10 day manned orbital mission

• **Value of the mission** in terms of added weightlessness experience and opportunity for more scientific experimentation

Studies conducted by McDonnell Aircraft Corp , prime Mercury capsule contractor, have considered MA-10 missions of 48 orbits (72 hr), 32 orbits (48 hr) and a repeat of Maj Cooper's flight A longer mission than MA 9 would require additional consumables, mainly batteries for spacecraft power They would be secured to the retro pack, and would be jettisoned with this pack on the capsule's re-entry

Cooper's Faith 7 capsule, McDonnell production capsule No 20, has been modified from previous manned capsules with the removal of the periscope, backup telemetry recorder, high frequency telemetry transmitter and the rate stabilization and control system The latter system one of the reaction control methods, was used only once for less than a second by Cdr Walter M Schirra in his MA 8 flight last October (AW Oct 8, p 26)

Maj Cooper will have a 1,500 and five 3,000 watt/hr batteries to power spacecraft systems Previous capsules have used three of the smaller capacity and three larger batteries

Hydrogen peroxide reaction control system fuel, which was expended during both Marine Lt. Col John Glenn's MA-6 and Lt Cdr Scott Carpenter's MA 7 missions, has been increased by 10 lb Cooper will spend much of his time in drifting flight, with no positive attitude control of his capsule He will have available 24 lb of manual control fuel and 42 lb of automatic fuel

The pilot will carry both ready to-eat bite sized food, and dehydrated food he will test for Gemini missions The food has a calorie value of 2,376 He also will carry 4 lb of drinking water in the capsule, with an additional 6 lb in his emergency survival kit

Maj Cooper will be the subject for a number of medical measurements and will conduct several scientific experiments (AW Jan 21, p 55) They are

• **Medical**—Sleep from ninth through the 15th orbit, urination at several specified periods, body temperature using an oral thermister instead of a rectal thermometer blood pressure, electrocardiogram using two chest and two rib sensors and two exercise periods, involving pulling a bungee cord requiring a 60 65 ft lb effort

• **Scientific**—Flashing beacon, to be released 15 min before sunset on the third orbit approaching Africa This will be used to evaluate the ability to acquire a target such as in the Gemini rendezvous mission The payload is a 5 75 in -dia sphere with flashing xenon lights Object is to eject the light package into a different orbit than the capsule so the two satellites will drift apart, and then to have the pilot sight the lights during about four orbits

Dim light phenomenon photography experiment is designed to acquire time exposures on colored film of zodiacal light and the night airglow Pictures will be taken with a 35-mm camera using a special f 6 lens developed by the University of Minnesota

Maj Cooper also will take horizon definition photographs to determine if the earth's sunlit horizon can be used as a reliable sextant reference during Apollo translunar missions The experiment, proposed by Massachusetts Institute of Technology, will call for photography with a 70 mm camera MIT is developing the Apollo guidance and navigation system

Radiation measurements will be made with two Geiger counters mounted on the retro-pack, a packet ion chamber stowed in the cabin, and an emulsion pack above the instrument panel

Tethered balloon experiment will measure atmospheric drag and allow the pilot to evaluate his ability to see it This test was marginally successful in Carpenter's flight The 30-in -dia balloon will be carried in the neck of the capsule and will be released on the sixth orbit It will be jettisoned during the seventh orbit, and Cooper then will attempt to track it precisely for 2 min

Other scientific experiments include photography of infrared reflections from the earth on the 17th and 18th orbits direct television camera evaluation using a 10-lb camera focused on the pilot or hand-held which can be read out at Cape Canaveral, the Pacific Command ship located south of Japan and Grand Canary Islands inactivating the cabin coolant system and using only the suit cooling circuit, measurements of antenna polarization with two 28-ft antennas observation of ground light using a 3-million candlepower light to be ignited on either the sixth or 21st orbits at Bloemfontein, South Africa, measuring the ratio of relative to actual star magnitudes to evaluate window attenuation and evaluating three types of white paint pigments on outer skin shingles to study re-entry heat effects

Recovery forces will consist of the aircraft carrier Kearsarge and nine destroyers in the Pacific the carrier Wasp 10 destroyers and an oiler in the Atlantic 100 aircraft and 27 contingency recovery teams around the world

Plan is to launch Faith 7 on a 32 5 deg orbit using a General Dynamics Astronautics Atlas 130 D The capsule will separate from the vehicle 306 sec after liftoff at an altitude of 528 400 ft and will be injected into orbit at a point 500 mi from Cape Canaveral If the flight goes according to plan the retro-sequence will begin 170 mi southeast of Kyushu, Japan

MA-10 Pilot

Washington—In astronaut assignments Cdr Alan B Shepard, Jr , and Maj Gordon Cooper share responsibility for the "remaining pilot phases of Project Mercury," indicating that Shepard will be the prime Mercury Atlas-10 pilot if this mission is conducted Shepard is Cooper's backup pilot for the MA 9 mission

Shepard and Maj Virgil Grissom are the only two qualified pilots among the original seven Mercury astronauts without orbital experience Maj Donald K Slayton was disqualified last year because of a heart condition Grissom is expected to be the first pilot to get out of a Gemini capsule while it is in orbit and to experiment with an extra vehicular space suit

VJ-101D Makes First Flight

First photo of the West German VJ 101D VTOL interceptor testbed taken during initial flight trials at Messerschmitt's Munich facilities, shows general configuration with podded wingtip engines for vertical thrust. Aircraft has been undergoing tethered flight trials since last summer (AW Oct 8 p 30) Full powerplant system has been in the Rolls-Royce wind tunnel for the past several months for vectoring tests

RAF Issues Order For 20 Beagle 206Ys

London—Royal Air Force after delaying the decision for a year, last week gave Beagle authorization to build 20 Beagle 206Y twin-engine utility planes, but left the door open for a future order for de Havilland Doves chief competitor of the 206Y

The Beagle 206Y will partially replace the aging Avro Anson Negotiations originally were based on a 40-plane order The third competitor was the Beech Queen Air which would have been supplied by Short Bros & Harland

Minister of Aviation Julian Amery said the Beagles will be built in seven-seat configuration and will be used primarily for communications duties It can also be adapted to accommodate two stretcher cases and attendants

Referring to the competition between Beagle and de Havilland Amery said it remains possible that the RAF will require more aircraft to replace the Ansons and the Dove was not ruled out as a replacement for some of these

The ministry previously had ordered two Beagles for service evaluation the only sales of the 206 series since it was first shown publicly at the Farnborough Air Display in September, 1961 Acceptance of a number of civil orders has been delayed pending the RAF decision, according to company officials

Martin Computer Interest

Martin Marietta Corp is showing an interest in the commercial computer field—indicated by its purchase of a block of Sperry Rand Corp stock—at a time when other aerospace companies are withdrawing from a crowded field

Election of George M Bunker, Martin Marietta president, to the Sperry Rand board is an indication Sperry Rand may be cooperating in the purchase When Martin bought into General Precision Equipment Corp. in 1961 on the open market, General Precision turned down Martin's request for representation on the board and filed an anti trust suit against Martin Martin sold its holdings though at a profit

Bunker said in a statement that Martin had extensive capability in defense electronics, but not in commercial areas He confirmed the stock purchase but not the amount This had been reported at nearly a million shares, or about 3% of Sperry Rand's outstanding shares

North American Aviation's Autonetics Div is the latest company to withdraw from the commercial computer field Besides earlier withdrawals by Bendix Corp and General Mills (AW Apr 15 p 112) price reductions on such equipment are beginning to appear.

Thrust-Augmented Thor

First photo of Standard Launch Vehicle 2C shows a Douglas Thor with three Thiokol solid-propellant motors strapped on to provide an additional 160,000 lb. of thrust. Total thrust of the vehicle is approximately 318,000 lb. and total impulse is approximately 32,200,000 lb./sec. Weight of the vehicle at lift-off is about 135,400 lb. Strap-on motors are Thiokol TX-33-52s with a specific impulse of 233 sec. and a sea level thrust of about 54,000 lb. per motor. Burn time is 40 sec. First launch of the TAT (AW Mar. 18, p. 36) at Vandenberg AFB was unsuccessful and the vehicle was destroyed when one of the solid-propellant motors failed to ignite. Second launch was successful.

U.S. Military Services to Increase Participation in Paris Air Show

Paris—U.S. military flying participation in the Paris Air Show June 7-16 will be considerably increased following protests to the Defense Dept. by U.S. aerospace companies taking part in the Paris show.

U.S. military services planned a fairly elaborate ground display of aircraft in Paris but only planned a single flyby of a Navy/McDonnell F-4B Phantom as well as the usual flying demonstration of the USAF F-100 Thunderbird stunt team.

This flying program touched off a protest by company members of the United States Aerospace Industries Representatives in Europe (USAIRE). The organization is made up of about 40 representatives of U.S. aerospace companies doing business in Europe.

At a meeting in Paris, Apr. 26, USAIRE decided to send a telegram protesting the "very inadequate" U.S. government support of the U.S. industry effort at the Paris Air Show.

The telegram, signed by E. L. Robbins, president of USAIRE as well as deputy director European area, Lockheed Aircraft Corp., was sent to Lawrence Levy, top Defense Dept. representative to NATO in Paris. The same telegram was sent to Dan Kimball and Col. Jack Bradley of the Aerospace Industries Assn. in Washington, to Henry Kuss, special assistant to the assistant secretary of defense, and to Thomas V. Jones, a member of the Defense Industry Advisory Council.

The telegram noted that the British industry "with full financial and official backing of the United Kingdom government" will fly 17 aircraft and helicopters. One day after U.S. information services in Paris confirmed the meager U.S. flying program, Robbins said he had been assured most of the U.S. military equipment on ground display would be flown. USAF sources in Paris later confirmed that "additional authorizations, amounting to $20,000 for flying costs, seemed to be in the works."

A DOD spokesman said an expanded flying program was being discussed, based on verbal protests from the industry group, and that the decision to authorize additional funds had been made before the telegram arrived.

USAIRE telegram also complained that "in light of the official exhortations to American defense industry to promote U.S. exports abroad and official promises of active support in this endeavor, it is difficult to reconcile the low level of effort on the part of the U.S. government to at least put its defense industries on equal terms with its European competitors by supporting a flying display of equipment."

U.S. military ground display at the Paris show will include F-4B Phantom, A-5A Vigilante, F-105 Thunderchief, T-39 Sabreliner and KC-135 tanker aircraft as well as several Army tactical aircraft and helicopters.

Aircraft flying will be the Grumman OV-1B Mohawk, Ryan precision drop glider (Rogallo wing), Northrop T-38, Republic F-105, Lockheed C-140, Lockheed C-130E, Kaman HH-43B, Convair F-106, North American A-5A, McDonnell F-4B and the Lockheed P-3A. There also will be a long distance redeployment of Republic F-105s from the U.S., and the Bell Aerosystems Rocket Belt will be demonstrated.

Telstar 2 Orbited

Cape Canaveral—Telstar 2 was successfully orbited from here at 6:38 a.m. EST last Tuesday and, judging from the quality of voice, television and other communications experiments conducted by the end of the week, it appeared to be as successful as its predecessor, Telstar 1, launched July 10.

Telstar 2 was placed in an orbit with an apogee of 6,702 stat. mi., a perigee of 604.7 stat. mi., a period of 225.4 min. and an angle of inclination to the equator of 42.7 deg. It was the 17th consecutive success for the Douglas Aircraft Co.-built three-stage Delta launch vehicle.

The American Telephone & Telegraph Co. communications satellite (AW May 6, p. 30) was exercised during its fourth orbit in an 18 min. transmission between the company's Andover, Me., station and the spacecraft. Transmissions included a 6-min. TV tape of Eugene J. McNeely, president of AT&T, and James B. Fisk, president of Bell Telephone Laboratories, and test patterns.

Telemetry beacon troubles occurred at 7:40 p.m. Tuesday when command transmissions to turn on the traveling wave tube in the satellite were made. The trouble was attributed to a poor satellite spin angle which resulted in a misaligned antenna and weak signal strength from Telstar 2.

Narrowing of the FM bandwidth of the command transmissions corrected the difficulty by increasing signal strength.

TV transmission from Maine to Europe via Telstar 2 will increase gradually from 45 min./day to a maximum of 3 hr./day on about July 20, 1963, and May 1, 1964.

Lenticular Comsat Proposals Asked

Washington—Industry is being asked to bid on a feasibility analysis and preliminary design of an inflatable lenticular passive communication satellite that would be oriented in space by the earth's gravity gradient.

Proposal request, issued by National Aeronautics and Space Administration's Langley Research Center, is for a cost-plus-fixed-fee study lasting six months. Bids are due May 14 at Langley, and a single contract will be awarded next month.

NASA feels that a lenticular vehicle has shown promise of providing a considerably greater reflectivity-to-weight ratio than a spherical satellite. In theory, an Echo-type spherical satellite must have a 400 ft. dia. and be injected into a 2,000 naut. mi. orbit to provide adequate communications capability. A lenticular shape with a 200-ft. radius of curvature in the same orbit is theoretically a better reflector.

Use of a lenticular shape requires that the same surface be oriented to the earth at all times, and for this reason the study includes analysis of using the earth's gravity gradient to stabilize the satellite.

If the concept proves feasible in the study, NASA may launch a small-scale lenticular satellite with a Scout vehicle. Scout could carry a 150 lb. model into a 700-mi. orbit to demonstrate the concept.

Companies invited to bid for the study are Aero Geo Astro, Astro Technology, Bell Aerosystems, Boeing, Chance Vought, Douglas, Fairchild Stratos, General Dynamics/Convair, General Electric, General Mills, B. F. Goodrich, Goodyear, Grumman, Lockheed, Martin, McDonnell, North American, Northrop, Radio Corp. of America and Republic.

NASA Report Shows 327 Objects Orbiting Earth, Sun; 312 Are U.S.

Washington—Total of 327 payloads, spent rocket motors and metal objects were orbiting the earth or sun as of Apr. 30, according to the most recent National Aeronautics and Space Administration Satellite Situation Report, which has been expanded to include U.S. military and "unclassified" Russian launches.

The report is the first available summary of man-made objects in orbit since Defense Dept. stopped supplying military and Russian launch data last September (AW May 5, p. 21). The summary does not include the May 7 Telstar 2 launch (see p. 36). NASA defines unclassified Soviet launches as those announced by USSR.

Analysis of the report indicates these highlights:

- **Platform for the Lunik 4** payload decayed Apr. 3, the day after the payload was launched from orbit.
- **U.S. is responsible** for 312 of the objects in orbit and USSR for the other 15. The objects include 57 U.S. and 11 Russian payloads. Of the U.S. payloads, 24 are military and five are in solar orbits. Four Soviet payloads are in solar orbit.
- **Twelve U.S. satellites** are listed as transmitting data, although presumably there are additional military and Soviet satellites which are returning information. Those transmitting are Vanguard 1, Transit 4A, Orbiting Solar Observatory 1, Ariel, Tiros 5 and 6, Explorers 14, 16 and 17, Anna 1B, Injun 3 and Relay 1. Tiros 5 stopped transmitting May 5.
- **Cosmos satellites** still in orbit are 2, 5, 8 and 11, launched last year, and 14 and 16, launched this year. Cosmos 13, launched Mar. 21, decayed Mar. 29, and Cosmos 15, launched Apr. 22, decayed Apr. 27.

By omission, the report indicates that Air Force failed in two of six attempts to orbit satellites this year. USAF announced Apr. 26 that it launched two satellites, one with a Thor Agena D and the other with a Blue Scout. Neither is included in the NASA summary. USAF also launched a probe Mar. 13 with a Blue Scout vehicle, which was not included.

However, if a probe is not aloft for at least 30 min., it is not given an international designation and is not listed in the summary.

Von Karman Dies

Aachen, Germany—Dr. Theodore von Karman, founder and chairman of the North Atlantic Treaty Organization's Advisory Group for Aeronautical Research and Development (AGARD) and internationally recognized aeronautical expert, died here last week at the age of 81.

Last February President Kennedy awarded Dr. von Karman the first National Medal of Science (AW Feb. 25, p. 21), saying he knew of no one who more completely represented "all of the areas with which this award is concerned—science, engineering and education."

News Digest

Series of long-range studies designed to establish concepts and requirements for a manned lunar base will be made starting next month by industry for NASA. Proposal requests for a general concept of a lunar base were sent to industry May 6. Study contracts will be awarded during the next 18 months to define a lunar life-support system, nuclear powerplant and regenerative fuel system for a lunar roving vehicle.

North American Aviation Space and Information Systems Div. and Space Technology Laboratories have been awarded $100,000 contracts by Ames Research Center to analyze spacecraft, boosters and trajectories for manned Mars missions. Other Mars mission studies sponsored by the National Aeronautics and Space Administration emphasize Saturn 5 vehicles. There is no restriction in vehicle or spacecraft in the NAA and STL studies.

North American X-15 No. 2, damaged in a crash last November, will be rebuilt with wing leading edges, control surfaces and portions of the fuselage coated with an ablative-type material designed to enable the research aircraft to withstand Mach 8 speed effects. Additional fuel tankage will be installed to increase engine burning time.

Radio Corp. of America will conduct a four-month engineering evaluation of a polar-orbiting Tiros weather satellite with two video cameras mounted on the periphery, 180 deg. apart. Satellite would orbit on its side and take one cloud cover picture every 3 sec.

Rocket Engine Test

Aerojet-General has successfully fired a 10,500-lb.-thrust mechanically throttleable liquid rocket test engine at Azusa, Calif., for 445 sec. with only a 1.3% growth in diameter of the glass fiber ablative throat. The engine, which was proposed to Grumman as a backup for the Lunar Excursion Module landing engine (AW Apr. 1, p. 23), met specified LEM performance requirements, according to Aerojet.

Chamber pressures ranged from 130 to 18.9 psi. over the 10 to 1 throttling range and gas temperatures up to 5,600F were recorded. The injector is a five-pintle arrangement with four oxidizer-metering pintles located symmetrically around a larger fuel-metering pintle. The oxidizer is nitrogen tetroxide and the fuel is an equal mixture of hydrazine and UDMH.

New York Airways Fights Survival Battle

World's Fair next year, flights from Pan Am Building expected to increase revenue for helicopter carrier.

By James R. Ashlock

New York—New York Airways lost $377,629 in 1962 and must obtain new funds for working capital and additional equipment—becoming the second of the three certificated U.S. helicopter carriers to reach a financial and operational crossroads.

Chicago Helicopter Airways was the first to encounter major handicaps, losing a key passenger source with the closing of Midway Airport. Los Angeles Airways improved slightly with a $122,000 increase in passenger revenue for the year ending last Sept. 30.

However, none of the three is yet at the point of non-subsidized independence and all face the threat of reduction or elimination of subsidy by Congress before they become self sufficient.

Robert L. Cummings, president of New York Airways, said at a stockholders meeting last week that the carrier cannot continue in its present status.

"We either go broke or we start expanding," Cummings said.

However, he stressed that passenger growth is such that it justifies hope for the airline's eventual success. Arrangements are under way to acquire the funds and equipment needed for improvement.

The $377,269 loss last year, which compares with $85,593 deficit in 1961, was blamed on subsidy reductions, bad weather and the problems of transition to turbine aircraft.

New York Airways is operating four Boeing Vertol 107 twin-turbine helicopters and has a fifth on order. The fifth, originally scheduled for delivery Mar. 1 but now expected in June or July, will cost $644,070. The airline has made a $193,221 down payment on it.

Outlining the carrier's financial needs, Cummings said $1 million must be obtained within the next few weeks for more equipment. The $533,000 needed to complete payment for the fifth V-107, its spare parts and ground support equipment would come from this amount.

Another $275,000 would cover the down payment on two more V-107s which Cummings says are needed. The airline, however, has not yet committed itself to that purchase.

"Also, the company has need of additional working funds which will be required in the next several months," Cummings said. "Arrangements for these funds are now under way."

While Cummings did not elaborate on the details of attracting additional finances, sources familiar with New York Airways feel that he will have little trouble gaining the necessary backing. Pan American World Airways had earlier proposed an arrangement by which it would invest in New York Airways' operation between the roof of the new Pan Am Building in downtown New York and Idlewild Airport.

Cummings said that improvement in passenger volumes and mechanical difficulties, coupled with the prospect of good business during the 1964-65 World's Fair, justified efforts to expand the airline's services.

Last month, New York Airways carried slightly under 23,000 passengers, 70.9% more than in the same month of 1962. The lowest monthly increase in passengers since last July has been 43.3%.

Certification of instrument flight rule (IFR) operations is expected this summer, and proving runs under Federal Aviation Agency supervision have already begun. During the winter months just ended, New York Airways canceled 19% of its schedules because of weather. Had it been able to operate IFR, such cancellations could have been reduced to 5%, Cummings said.

Mechanical problems, which accounted for 26% of schedule interruptions during 1962, reached a peak in August when 954 flights, 54% of the month's total, were canceled for mechanical reasons. This was compounded by serious delays in spare parts deliveries from Vertol.

"It was really rough," Cummings said. "At that time, we still hadn't received many of the parts we'd contracted for when we bought the V-107s."

However, he said Boeing readily acknowledged its responsibility and assigned up to 50 people to New York Airways' shops to correct the situation.

"Due to Boeing's fine cooperation, schedule cancellations for mechanical reasons had been reduced to only 2.5% by March, 1963," Cummings said.

Problems such as those encountered by New York Airways with the V-107 led Boeing's top management, which was mindful of the effect on the company's reputation, to initiate major changes in the Vertol organization, coupled with an engineering modification drive on the V-107 itself.

He noted that the General Electric CT-58-110 engines on the V-107s are now certified for 1,000 hr. operation between overhauls. The powerplants are operating with such reliability that they are not a factor in mechanical problems.

The airline has traded its five piston-powered Vertol V-44s in on the turbine V-107s. Cummings said that $785,000, the V-44s' aggregate book value, will be realized on the trade.

A key factor cited by Cummings in analyzing New York Airways' problems

New BUA Route

London—Italian government last week approved a British United Airways application to operate once a day between London-Gatwick and Genoa under a license approved by Minister of Aviation Julian Amery after strong objections by the state-owned British European Airways (AW Apr. 22, p. 40).

BUA, the largest British independent, currently is discussing details of the route with Alitalia, which has applied to operate services between Genoa and London. The British airline will use Vickers Viscounts.

The independent's application sparked off a bitter fight with BEA, when the state corporation applied to the Air Transport Licensing Board last March to have the license revoked. British United accused BEA of using influence with its pool partners, such as Alitalia, to freeze out the independent line. The charge was denied by BEA chief executive Anthony Milward.

Nevertheless, M. D. N. Wyatt, British United chairman, last week said:

"The officials of the Ministry of Aviation are to be congratulated on their conduct of lengthy and difficult negotiations which must have been made much more difficult by BEA's endeavours to frustrate them . . ." referring to BEA's attempt to obtain revocation of the license.

Dassault Mystere 20 Executive Transport Makes First Flight

First prototype of French Dassault Mystere 20 twin-jet executive transport has begun its initial flight test program (AW Apr. 29, p. 35). First flight lasted approximately one hour. Dassault plans to have the Mystere 20 on display at the Paris Air Show in June. French Air Force order for the aircraft may be announced during the show. Aircraft is powered by two Pratt & Whitney JT12A-8 turbojets.

was the government's subsidy reduction, which was compounded by late delivery of the turbine helicopters. The V-107s were originally scheduled to enter service in the spring of 1961, and Cummings said it was understood that the Civil Aeronautics Board would authorize $3.4 million in subsidy for the first year's service with them.

"If the V-107s had been ready for delivery at that time, there is no reason to doubt that the subsidy order would have been issued in the spring of 1961 as originally planned," he said.

Congress imposed subsidy reductions in both 1961 and 1962, and the V-107s were not delivered until last year.

"The subsidy available to New York Airways in support of the initial V-107 operations has now been cut from $3.4 million to $2,019,000, a reduction of more than $1.3 million, or 40%," Cummings said.

Result has been that instead of expanding services to New York suburban areas and increasing metropolitan frequencies, New York Airways has cut back to flights only between Idlewild and Newark airports and Manhattan's Wall Street heliport. Even service to LaGuardia airport, site of New York Airways' maintenance base, has been discontinued due to diminishing airline service there.

The carrier also canceled its late-night schedules formerly maintained for mail carriage. This resulted in its transporting only 554,986 lb. of mail in 1962, compared with 1,792,083 lb. in 1961. An official of the airline explained that the mail business was sacrificed because of the high cost of handling it on the ground.

"With local service airlines," he said, "the government subsidizes ground handling costs as well as air transport of mail. But it pays helicopter operators only for the flight time. We had to reduce service somewhere when our subsidy was cut, so we let the mail go."

To show the importance of subsidy in the future, Cummings said that 82% is the break-even load factor on the present four V-107s, based on non-subsidy operation. With five this would be reduced to 68%, and with seven, 62%.

"We must assume that we'll be granted as much subsidy in 1963 as in 1962, and hopefully a bit more," Cummings said. "That would bring our break-even point down considerably."

He said the airline had considered every means of cost-cutting, even the possibility of eliminating reservations and stewardess service.

"But many of our passengers still insist on making reservations," he said, "and the stewardesses proved invaluable on the two occasions when we made emergency landings in New York harbor" (AW July 23, 1962, p. 33).

Passenger traffic for New York Airways in 1962 totaled 194,184, an increase of 29.5% over 1961. Passenger revenues were $1,499,013 compared with $1,102,401 during the previous year. Total commercial revenues were $1,694,188 compared with $1,294,747 in 1961, and federal subsidy was cut to $2,215,832 from $2,587,111 in 1962.

Load factor dropped to 45%, the lowest since 1958, reflecting the 25-seat capacity of the V-107 compared with the 15 seats on the V-44. Direct operating cost per available seat mile on the V-107 is 14 cents, Cummings said, compared with 31 cents on the V-44.

"In 1954, our first full year of passenger service, our non-subsidy revenue equaled only 14% of total operating costs," he said. "Now, however, the Boeings are already earning 42% of these costs from non-subsidy sources."

Acquisition of the V-107s swelled New York Airways' long-term debt obligation to $2,574,533, compared with $87,718 in 1961. Bank loans, secured through chattel mortgages on the four aircraft, are payable in equal monthly installments until Mar. 31, 1969, at 5.3375% interest. The federal government guarantees the notes to 90% of the unpaid principal.

The company is also committed to buy $133,000 worth of additional V-107 spare parts and ground equipment.

As a result of the $377,629 loss in 1962, the carrier's accruing balance of retained earnings was reduced to $66,589, down sharply from the $444,218 on account in 1961.

New York Airways officials hope that the World's Fair and scheduled operations from the roof of the new Pan Am Building will increase its revenue.

About 70 million persons are expected to attend the World's Fair, and the carrier is negotiating with the Port of New York Authority to provide air service to the fair grounds (AW Sept. 17, p. 41).

Actual flight tests off the roof of the Pan Am Building must await approval of the city's Dept. of Marine and Aviation, and public hearings may be required. Helicopter crews have been making simulated approaches to the roof on a marked area at Newark airport.

Rooftop heliport is nearing completion, and officials of the airline say they have arranged with the FAA to begin tests when the city approves.

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BOAC to Reduce Fleet, Cut Staff by 800-900

London—British Overseas Airways Corp., already faced with planning uncertainties because of drag problems encountered during Vickers VC 10 testing, now figures that by 1967 it will need 10 fewer large jet transports than it now owns or has on order

Possible result of the airline's projection is that it could reduce the order for 42 VC 10s, or dispose of some of the 20 Boeing 707s now in service, or a combination of both A company official said BOAC probably would find the 707s easier to sell, since it is a proven project

Sir Basil Smallpeice BOAC managing director said on the basis of future planning, a staff reduction will be inevitable and company now is talking with union officials on best means of accomplishing this

Smallpeice said traffic figures for 1962 63 showed that BOAC increased passenger traffic on scheduled services by 4 6% and increased freight traffic by 25% but indications were that revenue has not appreciably increased

He cited two factors

- **New low promotional fares** introduced in past two years have not yet paid off in extra traffic
- **Independence to British colonies** operating their own airlines

A third factor is that London is losing ground as a gateway city to Europe

Smallpeice said BOAC now foresees a fleet of 52 airplanes in four years time of which 49 are passenger liners and others freight instead of 62 as formerly planned Fleet also would be composed of two types—the VC 10 and Boeing 707—using a common engine, the Rolls Royce Conway

The airline now employs 21,700 persons and, although the company declined to predict the amount of staff reduction, it is about 800 or 900

Braniff Panagra Offer

Dallas—Braniff offer to purchase 100% interest in Panagra from Pan American World Airways and W R Grace for approximately $22 million was filed by the carrier with Civil Aeronautics Board May 8

Filing which followed statement of the offer by Braniff President Charles E. Beard the week before (AW May 6, p 41) carried the additional information that the price offered was $22 million plus net earnings, after taxes, between Apr. 1, 1963 and the last day of the month preceding closing of the transaction Similarly, the price would be reduced by the amount of losses after Apr 1

Canadair Awaits TCA Decision

Decision on whether Canadair Ltd will contract with British Aircraft Corp or Sud Aviation of France to build components for the BAC 111 or the Caravelle jet transports rests on which aircraft Trans-Canada Air Lines selects to operate on its short medium haul routes

Late last month, de Havilland Aircraft of Canada signed a $65 million share-the cost pact with Douglas Aircraft Co for the production of airframe components of the DC-9 short range turbofan transport (AW Apr. 29, p. 35). Trans-Canada officials are negotiating with manufacturers for a new jet fleet with the understanding that some components will be built by a Canadian manufacturer through an arrangement similar to the de Havilland-Douglas plan

Joint participation principle developed when the Air Industries Assn of Canada proposed to the government that Canadian manufacturers share in the production of any aircraft purchased by Trans-Canada The government accepted the suggestion and Trans-Canada has followed the policy in its surveys of the aircraft market

The airline expects to decide on a new aircraft, which it will buy in increments of 10 up to a possible total of 50 late this year or early in 1964 Although it is studying all short-to-medium range aircraft available, the carrier specifically needs a transport with ranges up to 2,500 mi

FEIA Seeks Injunction Against American Airlines in Dues Dispute

New York—Flight Engineers International Assn has filed for an injunction against American Airlines' move to discontinue dues checkoffs on the payroll for the company's 650 flight engineers

The checkoffs which amount to between $7,900 and $8,500 in monthly dues paid directly to the FEIA were halted on grounds that the flight engineer contract has expired The company feels it is no longer obligated to perform the function

Asher Schwartz general counsel for the FEIA said the filing of briefs and answers on the injunction must be presented to Judge I B Wyatt of the U S District Court here by May 27

Schwartz said the union interprets the checkoff cancellation as a pressure tactic by the company in the current dispute over a new contract for American's 1,650 pilots (AW Feb 25 p 42)

The engineers have refused to join the pilots in the new contract until they are assured of job security and the right to negotiate their own wage and benefit provisions This has been denied them, Schwartz said by the pilots move to establish their own union the Allied Pilots Assn following a break with the Air Line Pilots Assn

Schwartz explained that failure to channel the dues directly to FEIA seriously handicaps the union's collections for its working fund The engineers he said feel the company is attempting to force them into joining with the pilots, thus establishing one union in the cockpit

"The union has had to rely on these dues payments to finance our contract negotiations," Schwartz said "We must compensate our representatives for the flight time they lose while doing union work, and this alone has cost between $5,000 and $6,000 a month"

The balance he said is taken up by hotel bills meals and the other incidentals associated with travel

Schwartz contends in his injunction request that under the provisions of the Railway Labor Act the company is obligated to continue the terms of the old contract until a new one is signed It has no right to delete a single provision such as the dues checkoff he claims

In another development ALPA expelled five American pilots who the union said were responsible for fostering the new contract and establishment of the Allied Pilots Assn ALPA has refused ratification of the proposed pact mainly because it does not require a commercial and instrument rating for flight engineers

Those expelled were Capt Nicholas J O'Connell chairman of the negotiating committee and temporary president of the Allied Pilots Capt Paul G Atkins, Capt Joseph P Garvey, Capt Robert T Guba and Capt J Richard Lyons all of the negotiating team

Atkins is a former international secretary of ALPA while Garvey and Guba once headed ALPA locals Garvey in Chicago and Guba in New York

ALPA has also asked the NMB to withhold action on the Allied Pilots certification request pending settlement of the court issues O'Connell countered with a telegram to the NMB saying that Judge Wyatt had specified earlier that the court matter should not interfere with the board's action

Turbine Powered Aircraft 1962 Operating Expense—Dollars Per Total Aircraft Hour

FLYING OPERATIONS	Total Hours	Crew Expense	Fuel, Oil & Taxes	Insurance	Rentals	Other Expense	Total	Less Rentals
BOEING 707								
Pan American	118,414	162.71	282.90	15.96	25.88	0.79	489.24	463.26
Trans-World	118,064	167.43	227.84	18.03	1.71	1.29	416.30	414.59
American	70,579	133.14	210.11	51.83		0.03	395.11	395.11
Continental	18,256	103.60	244.90	62.21		0.14	410.85	410.85
Braniff	10,651	105.38	239.00	89.69		0.65	434.72	434.72
Western	4,890	106.97	260.76	54.92	282.09		704.74	422.65
707 Average	56,809	152.81	245.03	29.44	13.63	0.76	441.67	428.04
DOUGLAS DC-8								
United	127,822	122.82	245.99	16.46		0.04	295.31	395.31
Pan American	65,234	169.70	300.15	19.43	27.76	35.40[2]	552.44	524.68
Eastern	39,749	151.64	267.44	73.95	45.72	0.03	538.78	493.06
National	25,976	89.95	192.60	52.51		160.80[2]	495.86	495.86
Delta	24,224	126.41	233.82	70.77	14.52		445.53	421.01
Northwest	16,735	131.33	303.26	79.45		0.85	514.99	514.99
Panagra	5,351	138.68	345.38	89.02		16.70	589.78	589.78
Trans-Caribbean[1]	3,580	65.88	252.32	112.82		0.41	452.43	452.43
DC-8 Average	28,585	138.40	259.67	37.59	12.90	21.37[1]	469.93	457.03
BOEING 720								
United	79,230	126.67	229.48	16.35		0.12	272.62	372.62
American	71,205	133.33	207.16	49.83		0.04	390.36	390.36
Eastern	37,644	139.69	208.48	68.79	134.53	0.01	551.50	416.97
Northwest	30,426	108.52	188.43	81.09	54.32	1.84	434.20	379.88
Western	15,335	105.48	241.76	68.13			415.37	415.37
Braniff	9,226	96.61	218.32	80.46		0.75	296.14	396.14
Continental	8,539	109.19	195.07	62.05	0.41	0.02	366.75	366.34
Trans-World	8,474	143.84	197.45	34.95	355.55	1.18	732.97	377.42
Pacific Northern	3,667	123.35	252.83	113.91		0.37	490.44	490.44
720 Average	29,306	125.89	214.23	49.82	36.90	0.33	426.38	389.48
CONVAIR 990								
American	16,891	136.32	240.51	68.19		0.04	445.06	445.06
CONVAIR 880								
Trans-World	51,659	154.05	209.73	20.10	0.18	1.55	385.61	385.43
Delta	39,058	122.43	210.81	60.80		0.01	394.05	394.05
Northeast[1]	16,782	104.20	221.88	78.47	264.08	0.10	668.73	404.65
Alaska[1]	2,857	124.19	287.54	112.66	33.85		558.24	524.39
880 Average	27,589	134.51	213.97	45.78	41.12	0.74	436.12	395.00
SUD CARAVELLE								
United	38,363	117.44	135.28	23.81		0.18	276.71	276.71
CANADAIR CL-44								
Flying Tiger	28,539	116.17	103.42	51.61		0.02	271.22	271.22
Seaboard	17,325	140.34	108.51	56.55		0.90	306.30	306.30
Slick	6,335	103.83	106.20	70.21	0.12	0.02	280.38	280.26
CL-44 Average	17,400	122.69	105.45	55.51	0.01	0.31	283.97	282.96
LOCKHEED ELECTRA								
Eastern	69,871	101.45	79.45	14.97		0.01	195.88	195.88
American	66,216	103.16	82.16	9.21		0.03	194.56	194.56
Northwest	39,777	84.66	85.31	30.64	0.21	1.12	211.94	211.73
National	33,842	92.62	75.56	16.66		0.03	184.87	184.87
Western	32,526	84.27	79.73	13.91	0.06		177.97	177.91
Braniff	21,500	88.94	70.00	20.66		0.74	180.34	180.34
Electra Average	43,987	96.58	79.78	16.44	0.04	0.24	193.08	193.04
FAIRCHILD F-27								
Bonanza	25,917	46.78	33.61	9.69	0.12	0.18	90.38	90.26
Piedmont	20,544	49.84	31.33	9.12		0.22	90.51	90.51
West Coast	19,994	51.34	35.47	7.12		0.05	93.98	93.98
Pacific	12,691	52.66	35.10	10.77		0.06	98.59	98.59
Aloha	11,997	42.50	35.49	11.57		0.01	89.57	89.57
Ozark	8,657	45.37	32.00	10.74	1.73	0.06	89.90	88.17
Average	16,633	48.44	33.78	9.52	0.18	8.11	92.84	81.86
No. Consolidated	4,294	55.94	62.48	16.78		1.20	136.40	136.40
Wien Alaska	2,969	53.10	67.98	20.59		1.07	142.74	142.74
F-27 Average	13,383	48.87	35.89	10.11	0.17	0.18	95.22	95.05
VERTOL 107								
New York	2,228	76.07	24.42	62.34		0.87	163.71	163.71
SIKORSKY S-61								
Los Angeles	1,880	41.31	18.22	56.93		1.27	117.73	117.73

DIRECT MAINTENANCE	Air-Frame	Engine	Other Flt Equip.	Total	Deprecia-tion	Total Direct Expense	Less Deprec & Rentals	Applied Maint Burden
BOEING 707								
Pan American	69.18	76.75	18.65	164.58	194.63	848.45	627.94	118.11
Trans-World	56.52	71.84	10.20	128.56	167.32	722.18	553.15	92.01
American	75.18	104.58	10.30	190.06	175.65	760.82	585.17	165.80
Continental	66.82	77.83	9.58	154.23	122.78	688.86	565.08	65.85
Braniff	69.41	69.73	7.62	146.77	183.29	764.78	581.49	56.27
Western	49.85	84.58	5.53	140.96	46.70	892.40	563.61	24.65
707 Average	65.64	80.76	12.99	159.39	174.97	776.03	587.43	113.36
DOUGLAS DC-8								
United	57.60	55.34	12.81	125.75	146.18	667.24	521.06	104.58
Pan American	87.74	65.08	32.12[1]	184.94	202.51	939.89	709.62	145.70
Eastern	71.35	72.24	12.40	155.99	172.85	867.72	649.05	72.17
National	54.38	94.48	8.49	157.35	122.54	785.75	653.21	61.38
Delta	78.41	91.36	1.99	171.76	224.62	841.91	602.77	104.88
Northwest	52.25	83.74	14.43	151.42	187.22	853.72	666.41	72.97
Panagra	272.29	134.67	39.72	446.69	225.22	1,261.69	1,036.47	24.05
Trans-Caribbean[1]	71.59	162.54	25.64	259.77	184.71	897.91	713.20	42.72
DC-8 Average	70.75	69.65	16.32[1]	156.93	170.59	797.45	613.96	101.79
BOEING 720								
United	43.58	37.21	12.07	93.86	102.32	568.80	465.48	82.10
American	62.08	104.07	9.60	175.75	166.76	732.87	566.11	152.07
Eastern	44.47	67.18	5.57	117.22	60.90	729.62	534.19	49.37
Northwest	28.88	90.22	10.03	139.13	124.67	708.00	519.01	65.99
Western	46.66	146.14	6.20	199.00	147.40	761.77	614.37	43.32
Braniff	57.56	72.49	2.60	132.65	144.54	673.32	528.79	43.57
Continental	54.86	54.95	7.49	117.30	138.97	623.02	483.64	45.95
Trans-World	25.68	79.89	9.53	125.10	66.80	924.87	502.52	100.79
Pacific Northern	88.41	69.19	6.85	164.45	158.23	813.12	654.89	60.80
720 Average	49.56	75.61	9.57	134.74	122.46	683.58	524.22	89.99
CONVAIR 990								
American	91.84	82.10	13.39	187.33	189.93	822.32	632.39	147.00
CONVAIR 880								
Trans-World	77.70	137.12	13.31	228.13	181.83	795.57	613.56	119.12
Delta	74.86	91.26	3.52	169.64	154.77	718.46	563.69	92.58
Northeast[1]	142.21	119.60	17.08	278.89	17.28	964.90	683.54	117.85
Alaska[1]	38.93	109.79	9.17	157.89	88.70	804.83	682.28	44.72
880 Average	85.50	117.52	10.31	213.33	144.82	794.27	608.33	107.64
SUD CARAVELLE								
United	50.21	64.71	14.41	129.33	175.54	581.58	496.04	96.00
CANADAIR CL-44								
Flying Tiger	51.96	118.08	44.45	214.49	147.59	633.20	485.71	53.23
Seaboard	69.29	104.41	20.59	194.29	140.09	640.68	500.59	71.35
Slick	22.45	141.74	12.23	176.42	157.97	614.77	456.68	30.47
CL-44 Average	54.13	116.42	32.62	203.17	166.36	683.58	487.13	59.49
LOCKHEED ELECTRA								
Eastern	36.44	71.57	15.19	123.20	166.56	485.64	319.08	46.53
American	38.06	99.66	25.29	163.01	127.15	494.72	357.57	62.96
Northwest	34.87	52.32	16.47	103.66	101.96	417.56	315.39	48.39
National	36.33	54.00	21.64	111.97	71.95	368.79	296.84	38.32
Western	31.43	87.58	14.66	132.67	122.57	444.21	311.58	22.96
Braniff	42.47	84.40	17.21	144.08	76.89	401.31	324.42	35.82
Electra Average	36.47	76.49	18.84	131.80	125.79	480.67	324.84	46.10
FAIRCHILD F-27								
Bonanza	26.75	18.73	7.74	53.22	25.89	169.49	143.48	13.89
Piedmont	31.29	14.62	7.82	53.73	24.32	168.58	144.24	18.08
West Coast	28.57	18.15	8.23	54.65	17.71	166.34	148.63	11.39
Pacific	28.56	22.39	9.85	61.00	31.31	190.90	159.59	26.61
Aloha	29.72	19.36	7.22	56.30	35.79	181.66	145.87	23.77
Ozark	40.26	18.84	7.13	66.23	21.29	177.42	154.40	22.63
Average	29.75	18.35	8.08	56.18	25.48	173.54	147.96	17.82
No. Consolidated				80.07	37.67	254.14	216.47	42.01
Wien Alaska				73.78	37.52	254.04	216.52	46.72
F-27 Average				57.55	26.23	179.88	152.60	19.59
VERTOL 107								
New York				163.87	56.63	384.21	327.58	68.70
SIKORSKY S-61								
Los Angeles				68.92	72.94	259.58	186.65	27.86

Data is for year ending Sept. 30, 1962. [1] Includes expenses of aircraft in interchange. Prepared by Roy & Roy

U.K., U.S. Disagree on Blind-Landing Plans

By Cecil Brownlow

Lucerne, Switzerland—Basic conflict over the operational modes, required complexity of the airborne instrumentation and the role of the pilot himself during all-weather operations envisioned for commercial aircraft during the early 1970s remains a hard reality—one that probably will be resolved along straight national lines rather than through any common system international agreements.

Known divergence between U. S. and British planners became more clearly defined here during debates at the 15th Technical Conference of the International Air Transport Assn., which had all-weather landing techniques as its prime concern.

U. S. airline operators and regulatory agencies—with a more-reluctant industry sometimes questioning their stand—remain committed to an essentially single-channel automatic landing system with the pilot retaining his traditional position in the control and command loop throughout approach and touchdown (AW Nov. 5, p. 47).

Taking a more united stand, United Kingdom regulatory agencies, manufacturers and airlines are looking towards multi-channel systems that would place the pilot largely outside the control loop but without taking away his command function over the aircraft.

Pilot Response

In one basic departure, based on their experience with test aircraft thus far, the British question a pilot's ability to respond to any emergencies after breaking out of cloud in a heavy jet aircraft at altitudes below 200 ft. and certainly at 100 ft. U. S. operators believe that with proper information from his instruments, he can make adequate responses and minimum attitude corrections as low as 70 ft.

Another factor, and one mentioned only occasionally by the proponents of either philosophy, is that most U. S. airlines plan to retrofit their present fleets of jet aircraft to accept new all-weather equipment now being introduced. Space limitations alone essentially preclude using a multi-channel system.

The British, on the other hand, plan no retrofits and are looking towards an all-weather capability only for new aircraft coming off the line where provisions for multi-channel units were incorporated into the original designs. Primarily, these are the Vickers VC 10, on order by British Overseas Airways Corp., and the medium-range de Havilland Trident, scheduled for the British European Airways Corp.

In one of the rare mentions of this particular factor, Alexander B. Winick, member of the Federal Aviation Agency's design team for an all-weather system, told the conference:

"The system design must be suitable for installation into the existing fleet of turbojet aircraft. The 707, DC-8 and 880/990 will be with us for many years, certainly through 1975. It is projected that in the early 1970s there will be close to a thousand such aircraft. . . .

"New aircraft types certainly are of importance but, as is well known, it is a much simpler task to provide an all-weather capability in such aircraft than to backfit the required components into existing aircraft."

Weather is an another factor and—with predictable worst conditions within Europe—is a major reason behind the British desire to proceed as quickly as possible to all-weather landing modes rather than on the step-by-step basis as envisioned by the FAA, the Air Transport Assn. and most U. S. carriers.

The meeting, probably IATA's largest technical conference with more than 30 airlines and over 70 U. S. and European airframe-avionic firms represented, was called primarily to consider three basic modes of operation:

- **Phase 1** as established by IATA to bring jet operations to within the present minimum values for propeller-driven aircraft—generally, a 200 ft. ceiling and half-mile visibility. Pilots of several U. S. airlines are certificated to operate their jet aircraft within this envelope.
- **Phase 2** to enable routine non-visual penetrations below 200 ft., requiring a fully automatic or semi-automatic approach, transition to visual reference and manual landing. Lower limits for this phase probably would be in the area of 100 ft. ceiling and a quarter-mile visibility. A number of British and European carriers are now operating near its upper limits. Phase 2 would incorporate standards for an improved category 2 ILS system.
- **Phase 3** to permit commercial aircraft to approach complete all-weather operations, the "ultimate airline objective," as defined by IATA. Plan incorporates fully automatic or assisted landings.

Equipment Standardization

British, U. S. and other representatives are, however, generally agreed that Phase 2 and Phase 3 ground equipment should be geared to ILS (AW Jan. 14, p. 20). Divergence in airborne equipment concepts can be tolerated, but disagreement over the type of ground installations could minimize the effectiveness of any all-weather system for aircraft used over international routes.

International Civil Aviation Organization committee currently is working towards standardization of directional ILS installations within its member nations although here, too, there are some disputes over the necessary reliability and, among some of the smaller countries, reluctance to accept the purchase and installation costs of advanced units.

In another area of agreement, both the U. S. and Britain concede that the ground and airborne instrumentation designed for Phase 2 operations must also be applicable to Phase 3, not only to eliminate duplication costs but also to provide the user pilots with experience and confidence in the equipment they will be called upon to use in an all-weather mode.

Most U. S. airline representatives here, including Pan American World Airways, Trans World Airlines and United Air Lines, are advocating a single-channel system embodying one auto-pilot, a monitoring flight director and two automatic flare units.

In the British approach, BOAC has ordered a duplicate monitored system,

Re-equipping Costs

Lucerne—Re-equipping for proposed Phase 2 and Phase 3 minimal-weather landing systems for jet aircraft (see story) will be an expensive item for the airlines involved but one that may promise a relatively-rapid return on investment.

Trans World Airlines, in an over-all study on the implementation of the two phases, estimates that its total losses this year because of inability to land its passengers at their scheduled destinations due to weather limitations could result in loss of up to $12.2 million for 1963 alone. Actual dollar loss for the year is estimated at $3.7 million.

A jet all-weather capability, the airline estimates, could have reduced these losses by an over-all total of $10.5 million and by an actual dollar figure of $3.2 million.

Estimates are based on a Federal Aviation Agency report which predicts that unacceptable weather margins will cost the U. S. domestic airlines a total of $67.7 million this year.

under development by Elliot Brothers Ltd. Unit embodies two completely separate systems, each with a working autopilot and monitor. Only one autopilot controls the aircraft at a given time, but the second is designed to cut in if and when the first should fail.

BEA Tridents will be equipped with a fully-automatic system designed by S. Smith and Sons, Ltd. Under development on a stepping-block basis, the system eventually will have a triple redundancy capability. Single-channel and duplex versions of the concept have been developed for the Royal Air Force.

Official of one of the British firms estimated the added weight penalty as something less than that of an additional pilot when compared with single-channel systems such as the Sud Lear Siegler unit now undergoing flight tests aboard a Caravelle jet transport at the French firm's Toulouse production facility.

Airborne Equipment

FAA concept for the airborne installation generally follows that of the American carriers. In an indirect reference to the resistance U.S. airlines might be expected to give to adoption of any multi-channel system in view of the aircraft needs, Winick told the conference that, if the unit "requires the rebuilding of the aircraft and a long period of aircraft time out of service, then it is simply not an economically feasible design and, therefore, there is little chance of acceptance. On the other hand, we realize that no essential element can be omitted and, therefore, a careful weighing of cost benefit factors will be required."

Regarding Phase 3, Winick also said that no one seriously thinks of all-weather operation in the complete sense. There must be, he said later, some forward visibility in terms of an RVR (runway visual range) value sufficient to provide roll-out guidance information. Exact requirements in this area have not been determined, according to Winick, although figures of approximately 750 ft. have been considered to be within reason.

For Phase 2 techniques, which FAA and most U.S. airline representatives here envision phasing into their jet transport operations by late 1964, the FAA official said the equipment must be based upon an optimum combination of both automatic and manual control techniques, with emphasis upon manual operations.

One problem still under study, he said, revolves around the best means of receiving a positive indication of the aircraft's arrival at 100 ft. Final choice, he said, may depend primarily upon the desires of individual airlines, the requirements of a particular aircraft or the needs for operating into a particular airport. Possibilities include:

- **Radar altimeter,** advocated by the Royal Aircraft Establishment's Blind Landing Experimental Unit for this task and generally accepted as a necessary part of a Phase 3 automatic flare-out unit. Because of terrain irregularities at some airports, Winick said, it sometimes may be impossible to use a radio altimeter to accurately determine arrival at the 100 ft. mark. "The extent that the radio altimeter may be unusable must be examined as it relates to individual airports," he said.
- **DME at ILS,** whose accuracy FAA hopes to refine. The FAA official said that it now appears that this type of information "could serve as a means of indicating arrival at the 100-ft. altitude point, although the DME error can result in an appreciable height error, perhaps 20% at 100 ft. This may be partially compensated for by the fact that information is continuously available, rather than being a momentary signal as from a marker beacon."
- **Precision inner marker,** a concept abandoned several years ago but now under re-consideration, for installation at an appropriate point to give positive arrival indication at the 100-ft. point.

Another requirement believed necessary for Phase 2 operations, Winick said, will be some type of safe go-around computer and indicator, several of which are now under evaluation by the FAA and by individual airlines.

The FAA official said a Phase 3 airborne system must have both an automatic and manual channel, with flare-out capability as an extension of the ILS, and using a radio altimeter as the final source of guidance.

Manual Capability

The automatic channel, under this concept, would be located on the co-pilot's side of the aircraft. The pilot would have a manual instrument capability, where the information displayed would be identical to that feeding into the automatic channel. In the event of a failure, the pilot would take command to execute either a missed approach or a manual landing.

In this regard, Winick noted that early work in flare-out systems in the United Kingdom "established that instrument landings could be made manually, despite the fact that other than optimum size instruments were used in that program. It is believed that a respectable percentage of successful landings were made in this manner, although the conclusion was reached by the authorities that the percentage was not sufficient for their purpose."

As a package, essential airborne instruments for a Phase 3 operation, Winick said, would include an automatic channel utilizing a radio altimeter, flare-out computer, a manual channel with the same signal outputs but displayed on the pilot's instruments and dual flight directors plus the equipment envisioned for Phase 2.

He added, however, that FAA will continue to support work on windscreen-type displays proposed by several U.S. avionic firms and that, when available, they could play a significant role in achieving pilot acceptance of Phase 3 operations, but they cannot be considered as a requirement at this time.

Report prepared for the conference by Joseph D. Blatt, director of FAA's Systems Research and Development Service, said SCAN techniques (i.e., Regal/Flarescan) "eventually may prove to be a necessary auxiliary to the standard ILS for future aircraft such as the supersonic transports. For optimum landing performance, these aircraft, when mixed with conventional jet or piston aircraft, may require variable glide angle characteristics which SCAN systems can provide."

Control Loop Design

In the discussion from the floor, a pilot's ability to react—and react correctly—when breaking out at low altitude under minimal weather conditions consumed a major portion of the debate.

British pilots, including RAF officers who have participated in the Royal Aircraft Establishment's blind flying test-flight program, were unanimous in their opinion that the pilot should be designed out of the control loop during Phase 3 landings. One BEA official said flatly that pilot responses under manual operations were limited at RVR altitudes below 400 yd. in situations where large jet aircraft are involved.

Some U.S. industry representatives also questioned the pilot's ability to respond properly when the aircraft might be within 3-4 sec. of touching the ground, particularly because of a reported tendency to under-estimate altitude and glide slope angle under minimal conditions. U.S. airline pilots, however, said they felt confident of their ability to take over and perform a manual flare-out in the event of a last moment auto-pilot malfunction.

As envisioned by the Air Transport Assn., first step towards Phase 3 would be to a 700 ft. RVR minimum for larger jet aircraft. Second might be landings without outside visual reference but with outside visibility for rollout. Third would be landing and rollout without outside reference but with sufficient visibility for taxiing. Fourth could be complete instrument landing, rollout and taxi without outside visual reference.

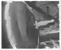
NEW B.F. GOODRICH FILAMENT WINDING FACILITIES PRODUCE GIANT STRUCTURES

Extending its capability for producing filament-wound rocket motor chambers and other products, B.F Goodrich has opened new facilities for even larger structures. Highlight of the new plant is the special winding machine (see photo) which can wind chambers up to maximum sizes for land transport.

This machine is designed to produce polar, helical, geodesic and circumferential winds—or any pattern that can be identified mathematically. Through a data track system, computer-developed winding patterns can be produced with extreme accuracy, under completely controlled environmental conditions.

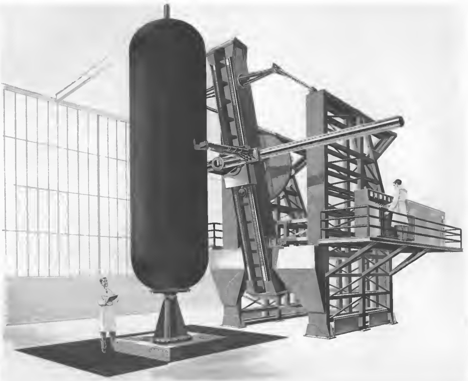
Included in the new facilities are winding machines for smaller structures, and large presses for molding rubber and plastic insulators. All associated materials control, curing, finishing, inspection, and testing are likewise provided in the new plant.

B.F.Goodrich offers a complete capability—we can help you in designing and producing light, strong, heat-resistant structures. For information contact *Department AW-5A, B.F.Goodrich Aerospace and Defense Products, a division of The B.F.Goodrich Company, Akron, Ohio.*



Filament wound rocket motor case

Rubber insulators for motor cases



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AIRLINE OBSERVER

▶ Airline industry's merger fever is still high Now under discussion is one of the biggest combines yet proposed—a three way merger of Northeast Air lines, Northwest and TWA Plan calls for an initial merger of Northeast and Northwest, with Hughes Tool Co playing an active part Donald W Nyrop, Northwest president, would head the combined organization If Hughes Tool can regain control of TWA, that carrier would be joined with the Northwest-Northeast firms, and Nyrop would be president of the merged group New merger moves probably will await the Civil Aeronautics Board decision in the American-Eastern case Approval would probably bring on a flood of merger applications, while disapproval would probably end merger moves for several years

▶ **Eastern Air Lines' success with its New York-Boston-Washington Air-Shuttle may lead to even more revolutionary operations by Eastern Now under consideration, for example, is a New York-Mexico City, low fare, no-reservations shuttle operation.**

▶ High hopes the British Overseas Airways Corp and Air France have for the Anglo-French Concorde supersonic transport are illustrated by changes in depreciation lives of the Boeing 707 jet transports the two carriers are now studying Plan calls for a 9¾ year depreciation period with a residual value of zero in order to have the 707 fleets fully written off when the Concorde goes into service The prevailing U S trend is to increase depreciation lives to 12 or 14 years

▶ **French certification tests for the Sud-Lear Siegler single-channel, all-weather landing system are scheduled to begin in October when the first Sud production unit is delivered Sud plans to produce three units per month System weighs 45 lb in its present configuration, but the weight could grow to 60 lb with added refinements now under consideration Planned selling price is approximately $60,000 per unit**

▶ Indian Airlines Corp has ordered three Sud Caravelles, equipped with Rolls-Royce Avon engines for delivery in August Order was delayed while the Boeing 727 was being considered but the government apparently was influenced by quick availability of the Caravelles It is still interested in the 727 for Air India The government was disturbed over Indian Airlines' shortage of high-speed transports when India's border dispute with China broke out

▶ **Most airline officials deplore the current rash of promotional fares, but little is being done to stem the flow of new ones Latest gimmick a TWA plan to extend the 50% military furlough fare to seven days after servicemen are discharged from active duty**

▶ Federal Aviation Agency's long struggle to assume control of military as well as commercial air traffic, and to operate all air traffic control facilities—2,100 operating units at 337 sites throughout the world—received a sharp setback last week After a year-long study, an interagency steering committee found that "general worldwide operation of U S military air traffic control facilities by the FAA cannot be justified on the basis of cost or operational efficiency" FAA campaign to take over all functions, under the name Project Friendship, began in October, 1959

▶ **French airport officials are concerned about the prospect of noise problems created by the joint British-French supersonic transport Design of the delta wing Concorde will require a 7-mile flat-out approach to airports at engine power settings producing a noise level approximately 16 decibels higher than that of the present subsonic transports.**

▶ Bitter personal feud between L B Maytag, Jr, president of National Air lines, and C T Baker, its former president, reached a climax last week when Baker filed a suit against Maytag in a move to void the sale of 100,000 shares of stock to Dudley Swim, National's chairman Baker charged that he was to have first chance to buy any of the 250 000 shares he sold Maytag in April, 1962, at $26 per share Swim bought the 100,000 from Maytag in June at about $15 per share

SHORTLINES

▶ **Aer Lingus** has ordered the BAC 111 for use on its European routes, as predicted by AVIATION WEEK & SPACE TECHNOLOGY (AW Apr 8, p 52) The four aircraft will be delivered in 1965.

▶ **Allison** 501-D13 turboprop engines have been given a 3,200-hr time between overhaul period on Lockheed Electras of American and Eastern

▶ **Central Airlines** stockholders have voted to approve a two-for-one split that will double company's common stock from 1 million to 2 million shares

▶ **Civil Aeronautics Board** and Federal Aviation Agency have merged CAB's "Airport Activity Statistics of Certificated Route Air Carriers" and FAA's "Air Commerce Traffic Pattern" into a single publication

▶ **Continental Air Lines** has adopted a policy of annual dividend payments, with an initial quarterly dividend of 5 cents per common share payable June 28 to stockholders on record May 31

▶ **Delta Air Lines** and Pan American World Airways have signed an interchange agreement that will provide single-plane service between New Orleans, Atlanta and Europe

▶ **Eastern Air Lines** has awarded a contract to Lockheed Aircraft Service for the conversion of a Lockheed 1049C Constellation to an all-cargo configuration, bringing the carrier's cargo aircraft total to five

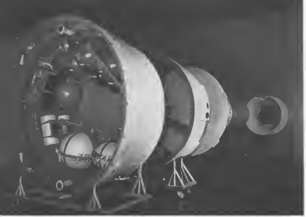
▶ **Emery Air Freight Corp** has found that 20% of the delivery time for an average air cargo shipment is spent in flight Balance is for pickup surface delivery, processing and transfers

▶ **FAA** has invited non-communist bloc nations to participate in a three-day all-weather landing system symposium beginning Sept 16 at Atlantic City

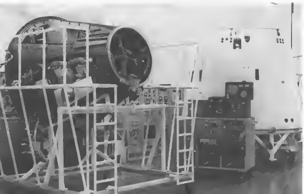
▶ **Flying Tiger Line** has reported a first quarter deficit of $1,276,351

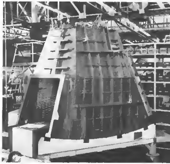
▶ **Japan Air Lines** has reported a 34% traffic increase on the transpacific route in April Alitalia had a 28% increase on the transatlantic route in March

▶ **March earnings** of $400,000 gave Eastern Air Lines its first profitable month since last year's flight engineer strike In first quarter, Eastern's losses totaled $3,350,000



GEMINI SECTIONS above are the equipment adapter (left) which houses maneuvering fuels, fuel cells and cooling pumps and radiators, retrorocket adapter section and crew compartment of re-entry module. Extreme right is Agena docking cone. Below is compatibility test unit in the systems assembly white room. It is a nonflyable Gemini used to verify design and installation of all Gemini systems.





ASTRONAUT JOHN GLENN sits in Gemini trainer (above left). Right is a partly completed manned pressure vessel on the production line at McDonnell Aircraft Corp. in St. Louis. Cockpit floor, including forward panel, is at left.

Gemini Design Keyed to Mission Flexibility

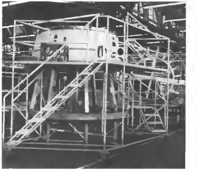
By George Alexander

St. Louis—Aircraft technology is the foundation for design, manufacture and testing of the two-man Gemini spacecraft, but it is overlaid with the experience gained by McDonnell Aircraft Corp. and the National Aeronautics and Space Administration during the course of the Mercury spacecraft program.

McDonnell has designed Gemini as it would an aircraft. The pressure vessel is a cockpit. Remainder of the spacecraft is a fuselage in which fuel is stored and systems are installed. Systems are accessible for maintenance through aircraft-type panels and the entire spacecraft has been built with the goal of high utilization rates always in mind. Gemini can accommodate a variety of systems and missions.

At present, NASA has programed only two missions for Gemini—rendezvous and long duration flight (AW May 6, p. 22). Air Force, which will participate in the program (AW Jan. 28, p. 26), has indicated that it will use the spacecraft for rendezvous-inspection of other possibly hostile satellites and shuttle transport to permanent space stations.

Gemini will be operated like an aircraft. Its two man crew will use the on-



ADAPTER MODULE of the Gemini spacecraft consists of two sections, retrograde and equipment, but is built as a single unit in this jig at McDonnell's St. Louis facility.

How Gemini Will Dock With Agena

National Aeronautics and Space Administration may attempt to fly a Gemini spacecraft on a direct-ascent, co-planar trajectory with an orbiting Agena D stage in their first rendezvous and docking mission. Rendezvous cube, that imaginary volume in space where the two vehicles would meet, would be the apogee point of Gemini's orbit, approximately 160 naut. mi.

This rendezvous plan, one of several under consideration, would impose a launch window measured in seconds on the Gemini-Titan 2 vehicle. The Gemini spacecraft would have to be launched a little less than 1 hr. before Agena—placed in a 160 naut. mi. circular orbit the day before—passed through the calculated cube. Perigee, or orbital injection point, of Gemini would be 87 naut. mi.

Also under consideration for the first rendezvous mission is a direct-ascent trajectory flown by Gemini, co-planar or nearly co-planar with Agena, in an expanded cube that would provide a larger launch window for the manned vehicle. Gemini would approach apogee no more than 10-15 deg. of revolution distant from Agena and use its propulsion system to catch the stage.

Gemini's rendezvous system consists of a Westinghouse Electric Corp. L-band radar, an array of four spiral antennas (AW Oct. 22, p. 72), and an International Business Machines Corp. digital computer. Interferometer radar signals are translated by the computer into range, rate and elevation data and displayed to the crew every 100 sec. in digital form and on an indicator with three needles for X, Y and Z axes. Effective range of the radar is expected to be about 250 mi.

Based on ground station tracking data and the pilot estimates of the situation, a decision is reached by the spacecraft crew and the Integrated Mission Control Center on the optimum point to begin the chase leg of rendezvous. More factors are involved than relative positions of the vehicles. Rendezvous initiation at one point might require four or five ignitions of the on-board propulsion system to close with Agena, but if delayed for several orbits when the orbital planes are converging it might be effected with only two ignitions.

When the decision is made, the spacecraft commander commands the computer by tapping out a coded signal on a 10-key keyboard to give him the orientation and magnitude of the velocity vector that must be added to Gemini to place it on a collision course with the target. The computer, using the radar data, does so and displays the vector in digital form on the X Y Z axis indicator and on the Delta V indicator. This last device gives the individual components of the vector.

The commander then fires his thrusters, which provide a velocity increment of 1.0 ft./sec./sec. longitudinally and 0.5 ft./sec./sec. laterally, until the required velocity vector has been added. He then shuts down the propulsion system and awaits further instructions from the IBM computer.

These corrections are issued automatically after chase has begun, and the magnitude of each should be successively less, both in attitude and acceleration. First correction will be on the order of 100-150 fps., the second under 50 fps.

Terminal leg of the chase will be flown visually by the Gemini crew—a distance as low as 2 mi. or as high as 20 mi.—using two high-intensity flashing lights aboard Agena for homing. Before docking to the stage, the spacecraft commander will determine Agena's status, indicated by five front-lighted dials, registering the safe "off" position of the main Agena engine, the amount of burning times remaining on the main engine and secondary propulsion system (AW Apr. 29, p. 19), the amount of gas left in the attitude control system, and the remaining lifetime on the batteries.

If all indicators are positive, the spacecraft commander aligns the docking bar, a 14 in. telescoping rod mounted on Gemini's rendezvous and radar module, with the center of a notched cone in the Agena adapter section. Tolerance is ±1 ft. or 10 deg. on any axis. Flickfiring the thrusters, the commander will close on the Agena at a forward rate of 1.5 fps. and a lateral rate of 0.5 fps.

As Gemini's nose enters the Agena adapter cone, coated with a dry film lubricant, three boat-hook type latches will trip and snap into receptacles on Agena. When the latches seat, three mechanical links on the aft end of the cone will retract and pull both Gemini and the Agena adapter sleeve against three hard points on the Agena stage. Solid docking will be indicated by a panel light.

After firing four small ullage rockets, two 16-lb. or two 200-lb. thrust rockets clustered around the main Agena engine to seat Agena's propellants at the pump head, the Agena main engine will be fired. Thrust can be used in this attitude as retro-thrust to reduce orbital height, or the Agena-Gemini combination can be rotated end-to-front and the Agena engine thrust used to increase orbit altitude.

When all fuel aboard Agena is expended—Lockheed is modifying Agena for a 5-day orbital duration—the Gemini crew will activate the release of the pull-down mechanism and the cone will snap back to its original deployed position. Should the latches fail to retract at this point, the crew can fire small explosive squibs to break the bond.

BEADED TITANIUM inner skin of double-walled pressure vessel is shown through personnel hatch.

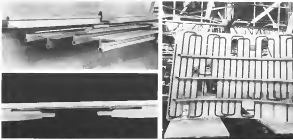
board propulsion system to fly to points in space dictated by mission objectives. It will re-enter the atmosphere with positive lift and land on a tricycle gear. Even the assigned roles of the two astronauts reflect those of an aircraft crew. The astronaut in the left-hand seat is the spacecraft commander and the man in the right-hand seat is the co-pilot/navigator.

Superficially, Gemini and Mercury are similar and the two-man spacecraft bears the imprint of its one-man predecessor in many respects. In reality Gemini is so advanced that it represents a new spacecraft, not a modified Mercury. In Gemini, the primary control mode is the human brain, not a sequencer.

The difference between a research and development manned capsule—Mercury—and an operational manned vehicle—Gemini—can be illustrated by the difficulty in replacing a part or subsystem on the former. "It seemed," said one McDonnell engineer, "that every time we had to replace something on Mercury it was always on the bottom [of the capsule]."

To get at the carbon dioxide absorber canister in Mercury's life support system necessitated the removal first of approximately 10 items of plumbing and structure. All the other systems, which may have been satisfactorily operative prior to removal, then had to be reinstalled and re-validated.

When replacement of this canister became necessary during one of the many delays in getting John Glenn's MA-6 capsule airborne, it took three 8-hr. shifts to accomplish the task. A



ADAPTER STRINGERS are delivered to McDonnell as 60 ft. long magnesium alloy extrusions (top left) then machined at intervals to leave only the tubing (bottom left). Gemini adapter module (right) is both equipment storage unit and radiator.

contributing factor to this lengthy operation, aside from the stack-upon-stack arrangement of systems within the capsule, was that only one man could work within the capsule at any time.

Although there is at present no complete Gemini spacecraft upon which to conduct a comparable operation, such a task is expected to require no more than a few hours. The reason is that the lithium hydroxide canister, as part of a life support system package, is directly accessible through a hatch at the external base of the two-man capsule. Several technicians, working side by side, will be able to open the hatch and remove the complete package. A new life support package can be inserted, mounted and connected, and the hatch refastened. Later, at the factory, the discarded package can be opened, a fresh canister inserted, and the entire unit used for a future flight.

Accessibility to equipment through hatches on the external airframe has been a cornerstone of Gemini's design (AW July 2, p. 94). It also is one of several reasons why Gemini has been a more difficult design and manufacturing effort than Mercury and why it has a more complex structure. Building a single conical vessel which serves both as pressure vessel and equipment bay is easier than it is to build specific structures for certain groupings of equipments—and a separate pressurized hull for pilots—and to integrate all these pieces into a balanced spacecraft.

Modularity has gone hand in hand with accessibility. All systems have been packaged and mounted as such on the structure, and they are easily removed and replaced. Since rendezvous mis-

McDONNELL TECHNICIAN adjusts lines in Gemini retrorocket ring.

... tight launch window restrictions on Gemini, McDonnell and NASA realized they could not waste hours on the launch stand looking for a burned-out component or loose wire in a subsystem. Instead the complete subsystem is designed for removal. A new one can be installed and repairs made to the malfunctioning unit at the factory.

McDonnell engineers say that the concept of modularity frequently has been misunderstood to mean that each system is wholly contained within one package. In fact some systems are scattered over the spacecraft in two or three separate packages. What the concept does mean, they emphasize, is that components are grouped in logical sets mounted on common chassis and attached to support racks on the structure.

Structurally, Gemini also is composed of modules. From front to back, they are:

- **Rendezvous and radar.**
- **Re-entry control.**
- **Cabin, including** the manned pressurized hull.
- **Adapter,** which consists of two separate sections, retrograde and equipment.

Forward Module

The rendezvous and radar module, the forward element of the Gemini spacecraft in launch configuration, houses the rendezvous radar, the stabilizing drogue parachute and the paraglider. In addition, it contains an ultra high-frequency (UHF) stub antenna, a male-type electrical connector and three latch receptacles; these last two items are devices involved in docking with the Lockheed Agena stage.

The module itself is a truncated cone 30 in. in diameter and 37 in. long atop a short cylindrical base, 9 in. deep and 38 in. in diameter. It is divided into fore and aft compartments by a transverse plate 9 in. below the top of the cone.

In the forward compartment, further subdivided by a longitudinal plate, are two cavities—the larger for the Westinghouse Electric Corp. rendezvous radar and the smaller for the drogue parachute. Both are delivered to McDonnell in flight-ready canisters and are inserted, including canisters, into their appropriate bays.

Aft compartment is a 9 cu. ft. cavity and the North American Aviation, Inc., paraglider is stowed there. Like the radar and drogue chute, the paraglider comes folded within its own container and, after insertion, needs only to be connected to the spacecraft's electrical harness. Because of development problems (AW Jan. 28, p. 55), the inflatable wing will not be ready for initial Gemini flights and will be replaced for ... a single 84-ft. diameter parachute.

Paraglider container has a slightly flattened face on one side that leaves a well in the aft compartment for the retracted nose skid of the landing gear system. Bulk of the nose gear is contained within the second module, however.

Construction of the rendezvous and radar module is of titanium throughout with the exception of the external heat-resistant beryllium shingles. Basic frame of the module is a semimonocoque structure of 10 stringers and four formers. On the inner side of the frame, the skin is of single thickness, 0.032 in. smooth titanium panels seam welded to the stringers. Beryllium shingles comprise the external skin of the module and are held in place by beryllium retainers so that this external surface expands and contracts uniformly under the heat load of re-entry and the cold soak of space. Retainers are bolted to the stringers with an intervening layer of insulation to preclude heat transfer into compartments.

Re-entry control system module is an 18 in. deep, 38 in. diameter cylindrical unit and primarily houses the attitude control system used only during re-entry. Besides the bulk of the nose skid landing gear, it also contains the tank of gaseous nitrogen, pressurized at 1,200 psi., which is used to inflate the paraglider.

Re-entry control system consists of two redundant and identical rings, identified as A and B, of eight 25-lb. thrust engines each. Each ring is pressure-fed from its own separate and independent set of propellant tanks and either ring is adequate by itself to satisfy the control requirements.

Paired Thrusters

Configuration of the eight thrusters in each ring is a pair of opposite facing engines every 90 deg. around the circumference. Thrusters are paired, those two jets which give the same rotation being fired together. The clockwise-firing thruster at 90 deg. is coupled with the clockwise-firing engine at 270 deg. to produce roll. For yaw, the counterclockwise-firing thruster at 270 deg. would be coupled with the clockwise unit at 90 deg. Thrust vector line of each thruster is tangential to the circumference of the module.

Propellant tanks are bladders within cylindrical titanium casings. Propellants—monomethyl hydrazine and nitrogen tetroxide—are positively expelled by gaseous nitrogen at 3,000 psi. in spherical tanks and ignite hypergolically in the thrust chambers. Chambers are ablatively cooled.

Re-entry control system normally will not be activated until about 5 min. before the Gemini crew intends to re-enter

the atmosphere. Primary control of this system rests with the digital computer in the inertial guidance system because of the difficulty pilots would have trying to move a control stick under the high g forces of re-entry. It is one of the few automatic systems that is aboard Gemini.

Construction of the re-entry control module is similar to that of the rendezvous unit. Basic frame consists of eight stringers and four formers. Inner skin panels seam welded to the stringers are of 0.032-in. smooth titanium and the external beryllium shingles are mounted on beryllium retainers. Six propellant and gas pressurization tanks—three for each ring of thrusters—are cantilevered off the aft end of the module. When all modules of Gemini are mated—or stacked,—these tanks protrude into the 19-in. deep space between the top of the cabin module airframe and the top of the pressurized hull.

Most difficult Gemini module to design, McDonnell engineers say, was the cabin because of the greater load concentrations expected. Mercury's loads, aside from the bending moments induced by the escape tower, primarily are columnar and compressive. In addition to normal dynamic loads, Gemini also will be subjected to tension and bending loads from ejection of the pilots' seats in the event of an abort, or from deployment of the paraglider and landing shocks. In addition, the bracing that takes out these concentrated loads also is required to support other structural elements.

Externally, the cabin module is a truncated cone 90 in. in diameter at the base, 38 in. in diameter at the top and 75 in. tall. The pressurized hull, or cockpit, is an irregularly shaped structure within this symmetrical airframe and resembles a blunted wedge. Airframe of the module is built around the pressure vessel, although one entire cockpit wall and part of another are common to both.

Pressurized hull begins to take form when the hatch section and the floor are joined together by six titanium longerons: four cornerposts and two centerposts. Aft cornerposts, where the cockpit is deepest, are about 65 in. long each. Centerposts are about 50 in. long and the forward cornerposts, where floor and hatch join the firewall, are about 35 in. long. All joints are fusion welds.

Side walls consist of four double-skin titanium panels, two panels to a wall. Inner skin of each trapezoidal panel is beaded and the outer skin smooth; both are 0.010 in. thick and are seam welded wherever the crown of a bead contacts the smooth skin. Vertical and horizontal titanium stiffeners, spaced about 6 in. apart and spot welded to the smooth side of the panels, make these flat walls load-bearing members as well as pressure containers. Panels are seam welded to the frame.

Large and small pressure bulkheads are, respectively, the rear wall and firewall of the cockpit. The large bulkhead is an elliptical dome 90 in. in diameter, of double-skin (beaded and smooth) titanium construction. An extensive cross-pattern of titanium stiffeners is spot welded to the beaded side of the dome. Two 45-in.-long machined aluminum rails, upon which the ejection seats are mounted (AW Apr. 29, p. 65), are bolted to the smooth, or pressurized, side of the dome with an angle of 24 deg. between their centerlines.

Small pressure bulkhead, or firewall, is 56 in. from the aft dome and is a flat keystone-shaped plate of double-skin titanium construction. It too is stiffened fore and aft. It is seam welded to the cockpit frame, unlike the large bulkhead, which is bolted to the frame.

Hatch section is the complete overhead of the cockpit and also comprises about a fourth of the external airframe surface. The section consists of a common sill and two hatches, the sill a trapezoidal frame of 0.5-in.-thick chemically milled titanium with a center piece dividing the frame into two hatchways.

Around the perimeter the sill is grooved, and the groove is filled with a silicon rubber sealant. A tongue-type extrusion of the hatches fits this groove and, when the hatches are closed and dogged down properly, a pressure-tight seal for the cockpit is formed. Each hatch, swinging on four hinges, is secured by 10 dogs, all of which, for normal ingress-egress, are manually con-

Gemini Power Systems

St. Louis—Electrical power for Gemini on-board systems will be drawn from two parallel fuel cell modules under development by General Electric's Direct Energy Conversion Operation, Lynn, Mass.

There are 32 individual cells connected in series to a stack and three stacks in parallel to a module or section. Sections are in parallel to the dual 22- and 30-v. main bus. Each stack delivers approximately 350 w.; total system has a peak power capacity of about 2,100 w., of which a little more than a third is used normally. Efficiency is about 50% according to McDonnell.

Fuel cell system weighs about 550 lb., of which about 200 lb. are supercritical hydrogen and oxygen, the fuels with which the cells operate. Fuels are fed into separate chambers on opposite sides of the cell (AW Apr. 9, 1962, p. 54) and pass through catalytic electrodes. Electrodes sandwich the GE-developed ion exchange membrane, key element of the cell.

Hydrogen atoms dissociate, giving up electrons to the anode and ions to the membrane. Ions travel through the membrane to the cathode, where they combine with dissociated oxygen and returning electrons to form water molecules. This reactant product is pure and is drawn off by wicks for storage and eventual consumption by the crew.

Fuel cell system has pilot controls for off-on power, water transfer to the cabin reservoir and emergency shutdown. Pilots will periodically shut down the cells to purge impurities which might otherwise interfere with the reactance process.

In addition to the cells, the Gemini spacecraft also carries four parallel 45-amp.-hr. silver-zinc batteries, weighing about 20 lb. each, to supply power to the main bus after jettison of the adapter module. Fuel cell system is contained within the adapter module, which is dropped prior to re-entry. There also are three high-discharge rate 12-amp.-hr. batteries weighing 8 lb. each, to provide power for control circuits and pyrotechnic devices. All these batteries, supplied by Eagle-Picher Co., are mounted in equipment bays on the side of the cabin module.

There are about 14 mi. of electrical wiring in the Gemini spacecraft, compared to about 7 mi. on the Mercury capsule. Wire bundles are assembled and checked on a three-dimensional board to make sure that all wires, pins and connectors have been correctly put together. These 3-d boards are dummy duplicates of spacecraft sections and the wire bundles are bent and routed as they would be on the spacecraft. On Mercury, the bundles were laid out straight and flat on 2-d boards and were not bent until they were installed on the capsule.

From the 3-d boards, the bundles go to a tube-and-cable mockup, a full scale dummy Gemini. The bundles are installed, connected and tested to determine that the routing is correct and that there is no cross-feed between wires. All connections between electronic packages and cables are of the crimped-pin type; there are no soldered connections above component level, as there were in several instances on Mercury.

These manufacturing and test methods, coupled with the fact that all bundles are routed on the outside of the spacecraft where two or more technicians can gain access to them, has reduced the time of installation about 90% compared with Mercury.


The new world of Command & Control
A big new problem is building up Out There. As man reaches out toward the planets, he faces such extremes of speed and distance that, unaided, he cannot cope with them. A way must be found to collect, process, and correlate immense amounts of data in milliseconds — and to display the results in such a way that the right decision can be made instantly. For man himself must make the ultimate decision. This is the real problem of Command & Control.
To this immense task, Lockheed has directed the nation's best qualified scientific staff. Experience? Working closely with the Air Force's Space Systems Division, they designed and built the USAF satellite tracking center at Sunnyvale, California, which has commanded, controlled, and processed data from more than three-fourths of all the satellites put into orbit around the earth. They are now laying the groundwork for the interplanetary Command & Control system that must become a reality in the '70's.
Lockheed
Lockheed Missiles & Space Company, Sunnyvale, California • A Group Division of Lockheed Aircraft Corporation

trolled by a ratchet wheel centrally located on the inside of the hatch

Each hatch is approximately 34 in wide at the base, 26 in wide at the top and 43 in long—compared with the 28–20 in width and 25 in length of the single Mercury entrance hatch In the middle of each hatch is a cutout for a teardrop-shaped pilot observation window about 71 sq in. in area A 5 in deep, 20 in wide scoop runs forward of the window for greater field of vision In comparison, Mercury's single window is more than 200 sq in in area and is flush-mounted in the sloping side of the capsule

The window in each Gemini hatch consists of three panes of glass the outer and middle panes of Vycor, developed by Corning Glass Works, and the inner pane of tempered glass Inner and middle panes are held by a common three-tined fork frame and the outer pane by an independent two tined frame Frames are bolted to stiffeners on the outer non-pressurized side of the hatches

Cockpit floor consists of two sections a forward 28 in long, 58-32 in wide trapezoidal panel upon which the pilots' feet rest and an aft 28 × 24 in, hatch directly below the seat pans of the two pilot couches This hatch is stepped out approximately 10 in from the forward panel to become part of the external airframe and opens into a compartment in which the cabin environment control system (ECS) package is installed

Because the pressure vessel is not symmetrically conical, six narrow triangular titanium shear webs are seam welded at right angles to the flat side walls of the

OVERHEAD HATCH frame (left) and floor (right) of the cockpit are joined by four cornerpost and two centerpost longerons. Environment control system access hatch is located at right

cockpit to provide shaping and attachment points for the external airframe Titanium ribs, at right angles both to the webs and the walls, complete the skeletal conical structure

External airframe is composed 75% of hatches, since the skeletal structure surrounding the cockpit divides this internal volume into eleven unpressurized compartments, which serve as equipment bays for the packaged systems There are five bays on each side of the cockpit s flat walls and two bays directly below the forward floor panel All are closed by hatches

Bay hatches are of the same general construction—smooth 0 10 in titanium inner panels seam welded to fore and aft stiffeners and beaded Rene-41 nickel alloy outer shingles bolted to the stiffeners, with an intervening layer of insulation between shingle and stiffener Hatches closing the pressure vessel have double-skin inner panels All hatches are approximately 1 in thick in cross section

Aside from the twin elongated hourglass shaped bays bracketing the environment control system hatch, where the main landing gear skids will be housed McDonnell and NASA are still considering several ways of distributing packages in the equipment bays

Whatever the distribution, all electronics packages in these bays will be mounted on cold plates with an interstitial layer of jelly—containing silver particles—between package and plate These plates are of three-layer aluminum sandwich construction with two separate and independent fluid systems circulated between layers Fluid is a commercially available Monsanto Chemical Co product and there is about 25 lb of the liquid in each loop

Packages are so designed that heat travels toward the cold plates Silver impregnated jelly distributes the heat evenly to the plate surface and the fluid picks it up there Heat then is carried through tubing to the adapter module, immediately below the cabin, where it is transferred to the skin of the module and radiated into space

McDonnell is building the heat shield for Gemini using a company developed ablative material McDonnell engineers say that although the shield has a 45% greater frontal area than the Mercury shield, it weighs only 4% more

The elliptical shield is separated from the large pressure bulkhead by a ½-in thick layer of insulation Circumference of the shield is flared slightly to provide an attachment flange This flange butts squarely against the base of a U-shaped bracelet ring around the base of the cabin Bolts are driven down through the trough of the U into the shield s flange to secure the two units

Cabin module is nested on an L-shaped steel ring in the top of the

adapter module. Three 1 in. wide titanium straps, buried among the cable bundles jumping the interface between modules, lock the cabin and adapter together during flight. By contrast, Mercury used a steel clamp ring to secure itself to its adapter. Gemini's nesting ring and tie-down straps will save about 40 lb. over a comparable-sized clamp ring.

Adapter module, consisting of two sections but built as a single unit, serves both as a radiator and an equipment storage section. It is a truncated cone, 90 in. tall, with a 120 in. diameter base, and 90 in. diameter top. Separation plane between the two sections—retrograde and equipment—is about 55 in. from the base.

Stringers in the adapter serve a dual purpose. They stiffen the structure and they carry the tubing of the circulating fluid-coolant system. Stringers have a T-shaped cross section, with a 0.25 in. diameter tube on the bottom of the shank. They are delivered to McDonnell as 60 ft. long extruded units.

At 34-in. intervals, the T section is removed from the extrusion for a distance of about 6 in., leaving only the tube section. The tube then is bent to a U shape in the cutout area. In this way, McDonnell makes 18 separate stringers but only one continuous tube from a single piece of material. Four 60-ft. pieces are required to make the 72 stringers in the retrograde section of the adapter. Tubes are joined with flared fittings at the junctures of the four pieces.

Fluid circulating through the cold plates in the equipment bays of the cabin module is ducted to one of two jump-off points one for each system, at the base of the module. There, the

PRESSURE BULKHEAD which forms rear wall of the Gemini cockpit shows mountings for the aluminum rails on which ejection seats rest. Rubber guards are for plant use.

tubing is routed outside into a faired tunnel across the interface and then brought back inside into the top of the adapter.

Moving down the length of the retrograde section in the hollow stringers, the heated fluid transfers its heat through the T section to the module's external magnesium skin. Upon cooling, the fluid is pumped into the cabin module again.

Surface area of the adapter is about 190 sq. ft. With the exception of some hatches, this entire surface is used as a radiator. Magnesium was chosen as the skin for this module because of that metal's good heat transfer characteristics.

Construction of the retrograde section is mostly of magnesium alloy. External skin panels are of 0.032 in. magnesium alloy and the extruded stringers are also magnesium alloy. The four circumferential formers however are of aluminum alloy for greater structural rigidity.

Retrograde section houses four Thiokol Chemical Corp. solid propellant retrorockets each rated at 2,500 lb. thrust. The 13 in. dia. spherical motors are mounted independently on a four-legged aluminum spider beam within the conical section. For re-entry, the motors would be ripple fired and their burning times overlapped. They would be fired in salvo to separate the spacecraft from the Titan 2 launch vehicle, if an abort situation arose during the boost phase of flight at altitude.

Six thrusters, two 85-lb. and four 100-lb.-thrust units, are also located on the retrograde section. They are part of the Orbital Attitude and Maneuvering System (OAMS).

Equipment section of the adapter module also is a magnesium alloy construction in the external skin panels and the stringers. There are 88 stringer/coolant lines and five circumferential formers in this part of the module. Formers are of titanium instead of aluminum as in comparable rings in the forward part of the module.

Equipment section, which is closed by a thermal curtain on its broad end to prevent solar radiation on cryogenic systems located there and by a glass fiber shield on the forward end to protect those same systems against retrorocket exhaust, houses:

- **Fuel cell system.**
- **OAMS tankage and control,** and 10 thrusters.
- **Electronics.**
- **Environment control system.**

Each of these systems is packaged on support frames as integral units and is suspended from the skin structure. Access to the systems installed within the adapter module is limited, once mated to the Titan 2 launch vehicle, because of the radiator structure on the inner

skin. Unmated, however, the packages are easily pulled off and replacement systems installed.

The Orbital Attitude and Maneuvering Systems (OAMS), as the name implies, is the on-board propulsion system which will make Gemini a genuinely operational spacecraft. The Mercury capsule's orbital parameters were determined by its Atlas booster. Gemini, propelled by OAMS, will have the capability of correcting its orbit to desired or pre-determined parameters and will be flown much like a high-performance aircraft.

The OAMS system consists of 16 thrusters:

- **Two 100-lb. thrust engines,** located 180 deg. apart on the aft rim of the adapter module, provide forward acceleration.
- **Two 85-lb. thrust engines,** located 180 deg. apart on the forward end of the retrograde section of the adapter, provide deceleration.
- **Four 100-lb. thrust engines,** located 90 deg. apart on the forward end of the retrograde section, provide lateral displacement of the spacecraft. Their thrust vector lines are perpendicular to the spacecraft's center line.
- **Eight 25-lb. thrust engines,** located every 45 deg. apart on the aft rim of the adapter, provide pitch, roll and yaw control to the spacecraft. Thrust vector lines of these eight engines are tangential to the spacecraft. These engines are always fired in pairs, like the thrusters in the re-entry control system.

All 16 thrusters are pressure-fed from common propellant bladder tanks—nitrogen tetroxide and monomethyl hydrazine. Helium is the pressurizing gas and represents a weight savings of approximately 20 lb. over a comparable amount of nitrogen. For the short two-day rendezvous mission, where the Gemini crew will attempt to meet and mate with an Agena stage, the OAMS propellant tankage will be augmented with duplicate tanks of fuel, oxidizer and pressurizing gas. For the long duration—above three days—missions, only one set of tankage will be used. Extra set of tanks adds about 700 lb. and partly explains the heavier (7,800-lb.) weight of the short duration configuration over the long duration (6,800-lb.) configuration.

The eight translational thrusters of OAMS—the six 100-lb. and the two 85-lb. thrust engines—will be controlled by the spacecraft commander only, using a maneuverable stick on the instrument panel before him. The stick, with a ball knob, resembles the choke on an automobile. Pushing the stick straight in causes the decelerating 85-lb. thrusters to come on. Gemini, unlike Mercury, flies small end first in the same direction as the pilots face.

Four 100-lb. thrusters around the retrograde section are fired singly and displace the spacecraft in the direction of thrust. For example, if during a rendezvous attempt, the spacecraft commander observed that the Gemini was misaligned only laterally with the Agena, he would fire either the thruster on the port or starboard beam to move the spacecraft into position.

At one time, NASA and McDonnell considered the addition of a duplicate OAMS control stick socket on the co-pilot's side, so that the single stick could be plugged in on either side of the panel and used by either pilot, but this idea was dropped.

Attitude is controlled by a side-arm stick mounted on the console between the pilots. Either pilot can use it; the commander with his right or the co-pilot with his left. There are five control modes for attitude:

- **Direct.** This corresponds to the fly-by-wire mode of Mercury. Movement of the stick triggers a direct electrical impulse to the valving on the appropriate 25-lb. thrusters. It is a manual mode, and whatever energy is put into the spacecraft must be taken out by countermovements of the stick once the desired attitude has been achieved.
- **Rate.** Second of three manual modes, this method is very similar to the rate command system of Mercury. Movement of the side-arm stick triggers thrusters corresponding to the direction of the control movement. However, when the pilot has the spacecraft oriented as he desires, he simply releases the stick and the system automatically damps out any further turning rates.
- **Pulse.** Third manual mode, the pulse system causes the thrusters to fire in short bursts of 06 deg./sec. As in the direct mode, the pilot must take out whatever he puts in after he has achieved the desired attitude.
- **Horizon scan.** One of two automatic modes, this system uses inputs from infrared horizon scanners on the forward end of the cabin module to align the spacecraft within ±5 deg. in pitch and roll. It is comparable to an aircraft's automatic pilot.
- **Re-entry.** Used only during re-entry, this automatic mode translates guidance system signals into commands for the thrusters in the re-entry control module (the adapter section is jettisoned prior to re-entry). It damps out undesired pitch and yaw moments and generates a steady roll rate of 20 deg./sec. when the correct re-entry trajectory is achieved.

There is no direct mechanical linkage between the side-arm stick and the thrusters, as there was in Mercury. Pilot will select one mode at a time with a rotary switch, turning it to the appropriate stop for the desired mode. This will preclude two modes being in oper

ation at the same time, as happened on Scott Carpenter's MA-7 flight.

Side-arm stick travel is 10 deg. in any direction. In any mode other than rate command—where a flick will cause the thrusters to come on—the stick must be moved at least halfway to the stop limit before the thrusters fire. There is no proportionate scaling of stick motion to thrust level—the engines either are on at their nominal rated values or off.

An unusual feature of Gemini's on-board propulsion system is the absence of any screws or bolts in fittings. All propellant and pneumatic lines of stainless steel are joined by brazed sleeves wherever one line connects to another. Components, such as valves, regulators, fillers, solenoids, etc., are welded together in packages; all OAMS control components are contained in five such packages. If a valve should stick or a regulator fail during check-out of a spacecraft, the sleeves immediately upstream and downstream of the package containing the faulty part would be opened and the complete package removed. A replacement package would then be installed and the sleeve connectors rebrazed to seal the system once more.

Environment control system is divided into two packages, one in the cockpit and the other in the adapter. Major elements of the ECS include the oxygen reservoirs, oxygen purification, personnel cooling, water management and egress oxygen/cooling.

Gemini carries two breathing oxygen reservoirs, a 104-lb. tank of supercritical and a 15-lb. tank of gaseous oxygen. Large tank, the primary reservoir, is located within the adapter module and would be used only on long duration flights. Smaller tank, called the secondary reservoir, is located within the cockpit and would be used on both long and short duration missions. It provides breathing oxygen during re-entry.

Oxygen supply, purification and suit cooling are all on a single loop. Pilots' suits are connected in parallel to the loop, however, and fitted with individual regulators so that each man may set flow rates according to his own desire. With the face plates of their helmets closed, exhaled breath is vented through a suit outlet and ducted through a compressor to the purification module. There, lithium hydroxide reduces carbon dioxide, charcoal filters remove odors and wicks absorb any moisture. Purified gas then passes through a heat exchanger (a finned unit around which the Monsanto coolant fluid circulates) where it is cooled. Downstream of the exchanger, the recycled oxygen is mixed with fresh oxygen and then ducted back into the suits. When the face plates of the helmets open, the cycle would be the same except that exhalation would be into the cabin and the inlet on the compressor would be opened to draw in the gas.

Cockpit Pressure

Gemini cockpit, according to present NASA plans, will be pressurized to 5.1 psi. with 100% pure oxygen. Cabin and suit pressurization systems are separate but interconnected.

Drinking water is drawn from a 16-lb. capacity tank within the cockpit. It always contains at least 13.5 lb. of water and is partially filled prior to launch. After launch, the fuel cell—as a reactant product—delivers approximately a pound of water for every kw. hr. and this is ducted into the storage tank by the pressure differential between the two systems. Mouthpiece fits a plug in the pilot's faceplate to allow drinking even if the plate should be closed.

As part of the total water management system, body perspiration not evaporated by suit cooling will be drawn off by wicks and dumped into a storage tank in the cabin module. Urine also will be dumped into this refuse tank. Liquid stored in this tank can, if necessary, be used for augmentation of the coolant system.

An egress oxygen/cooling system is built into the pilots' ejection seats. In the event of ejection, the system is

Gemini Practice Pod

Gemini crews will practice rendezvous in space, probably on the fifth or sixth flight, with a 65-lb. pod before graduating to an Agena D stage on the sixth or seventh flight.

The pod, called a Rendezvous Exercise Pod (REP), will be built by Westinghouse Electric Corp. It will mount two flashing lights, a beacon transponder and an omni-directional antenna and will be carried piggyback into space in Gemini's adapter module. Once Gemini is in orbit, the pod will be jettisoned at an angle from the spacecraft and given a slight tumbling rate for heat balance. It is expected to drift at least 5-10 mi. but no more than 50-60 mi. away. Useful life of the pod—3-6 orbits—will be determined by the life of its batteries.

During the first and probably second orbit, the Gemini crew will exercise the rendezvous radar and computer against the pod's transponder but will not fire the Gemini propulsion system. What would have happened had the thrusters been fired will be estimated by the IBM computer. During the third orbit, the crew will lock its radar on the transponder and, with velocity and angular data provided by the computer, fire the thrusters and attempt to approach within 100 ft. or less of the pod.

triggered and provides the pilots with breathing and cooling oxygen, as well as pressurizing their suits

Inertial guidance system of Gemini consists of a stablized platform built by Minneapolis Honeywell Co and a digital computer developed by International Business Machines Corp. During the boost phase, this inertial system is a back up guidance unit to the radio inertial system under adaptation from the Mercury/Atlas vehicle to the Gemini/Titan 2 (AW Sept 3, p 38)

After separation of the spacecraft from the Titan 2—accomplished by firing the two 100-lb thrust OAMS engines on the rim of the adapter module—the IBM computer will check the orbital insertion parameters If lower or higher than planned values the spacecraft commander will use the OAMS thrusters to place his vehicle in the desired position

Primary function of the guidance system is to lead Gemini to its Agena target vehicle in rendezvous missions The Westinghouse L-band rendezvous radar, an array of four spiral antennas (AW Oct 22 p 72), provides angular and range data to the computer on the relative positions of spacecraft and stage

Inertial guidance system also plays a major role during re entry All through orbital flight, the computer constantly determines the latitude and longitude of the spacecraft and predicts future plots so that the crew will know which possible landing sites are available in emergency

If the crew is interested in a particular landing field it will enter the coordinates of the site into the computer which then determines whether the site is within reach or whether the capsule must be maneuvered to a new heading

Computer not only indicates the vectors of the maneuver but also gives a target time for firing the retrorockets This use of the guidance system is called the orbit navigation mode

At the time of retrofiring the computer is supplied with this data from ground stations

- **Orbit parameters** as determined by ground tracking stations
- **Coordinates** of the landing site
- **Relation** between the orbital plane and the plane of the landing site

Using this data the computer then predicts the range distance to the site based on a zero-lift trajectory and computes the position of the spacecraft in relation to the site coordinates The difference between the prediction and the computation is an error signal output which the computer sends to the re entry control system to fire selected thrusters.

Attitude of Gemini during re entry is such that the pilots are held down, looking at the earth, with their backs to the direction of flight The spacecraft's center of gravity, offset 1 5 in from the vehicle's center line is located in the area of the ECS system, that side of the capsule facing toward space during re-entry Its placement causes the spacecraft to trim out at an angle of 16 deg from horizontal

Firing of the thrusters causes the center of gravity to be rolled back and forth over a 180-deg arc but the cg is always maintained on the upper or space-oriented side Positive lift control is thus provided letting the capsule roll more than 180 deg would place the cg on the earth side and result in negative lift

Displacing the center of gravity off the center flight path line results in the spacecraft banking in that direction to a degree proportional to the displacement In this way, out-of-place misalignments between re-entering capsule and its landing site can be corrected to co-planar

This offset center of gravity can only extend the range of a re-entering Gemini, it cannot shorten it For this reason the computer introduces a bias in the time of retrofiring so that the crew must use the lift of the offset

center of gravity to reach the landing site Maximum life occurs when the center of gravity is perpendicular to the flight path trajectory Zero lift occurs when the spacecraft is in a steady roll

Landing footprint of Gemini, i e the extent to which it can be maneuvered during re-entry to reach one or more landing sites is 450-naut-mi long and 90 naut mi wide

Re-entry begins with the jettison of the adapter module This is achieved in two steps First a shaped charge between the retrograde and equipment sections is fired this not only severs the airframe, but also cuts and pinch seals all coolant and ECS lines between the two sections of the module This same charge also drives a series of razor sharp blades called guillotines through electrical bundles and OAMS propellant lines Signal to activate the charge is delayed about 0 5 sec to allow a switch to shut off the current flow downstream of the charge and thus prevent short circuiting

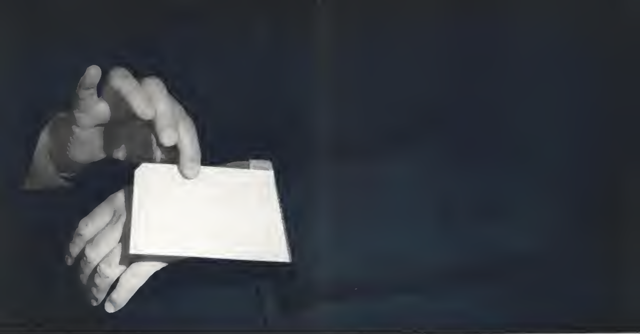
About 5 min later, with the equipment section now well behind the spacecraft is turned around by the crew to a heat shield first attitude and pitched up to the proper angle The Thiokol retrorockets are ripple fired to slow the craft Explosive squibs cut the titanium straps holding the cabin module to the retrograde section and also drive two guillotines to cut the wire bundles, coolant lines and ECS lines in the tunnels bridging the interface between modules Retrograde section then is jettisoned completing the second phase of adapter jettison

Spacecraft Re-entry

The spacecraft then re-enters the atmosphere and once the correct ballistic trajectory to the landing site is attained, goes into a 20 deg/sec roll at about 60,000 ft A small mortar is fired by the crew, opening the top of the drogue chute canister and deploying this small stabilizing parachute

At about 50,000 ft, the rendezvous and radar module is released from the re-entry control module by explosive bolts and the drogue chute pulls the entire module clear of the spacecraft In so doing it also dumps the folded paraglider from its bucket like glass fiber container

Attached at the nose and tail by clamps to the forward end of the re-entry control module the full 30 ft length of the glider emerges as a U shaped loop Tail clamp on the dorsal side of the module is released first The end of the paraglider travels toward the base of the spacecraft and pulls its associated cabling free from the 1 5 in deep trough which runs the length of the cabin module between the hatches Cables are laid in this covered trough prior to flight



With this partial deployment of the glider, the spacecraft begins to pitch over from a vertical to a horizontal position The nose restraint then is released and the attachment point slides on a rail from the ventral to the dorsal side of the re-entry control module Deployment of the forward end of the glider triggers a winch in the re-entry control module to pay out the nose cable

There are three cable systems on the paraglider. The nose cable, at the junction of the wing's three booms is fixed The center cable is the pitch controller and runs from the aft end of the center boom down to the reel box in the spacecraft and then up and forward to the nose cable attachment The outer cable controls roll axis and runs from the end of one outer boom to the other through the reel box

The reel box is located under the hatch section of the cabin module, above and between the pilots' heads Reel drums are pneumatically driven and actuated by the side-arm control stick used during orbital flight for attitude control Pilot makes normal aircraft control movements with the stick, which are translated into take up or pay-out commands for the reel drums Spacecraft is shifted relative to the glider so that the center of gravity for the wing-capsule system is changed Dive flare or bank attitudes therefore are possible

Nose landing skid is automatically extended at the time of paraglider deployment Main gear are dropped by the crew after the wing has deployed fully and the craft has stabilized Touchdown speed is expected to be about 76 fps and landing roll about 200 ft Skids have limited knuckle-type freedom around the pitch and roll axes and are spring loaded for a slightly pitch-up deployed attitude

McDonnell recently has completed an extensive series of tests on the landing gear with scale models Models were quarter-scale dimensionally and one sixteenth scale in weight and were instrumented to measure vertical and lateral impact loads drag and stability during landing roll A variety of metal soles have been tested on the skid shoes, including stainless steel and aluminum, but no decision on a final material has been made yet It will however, be a smooth metal

Tests have been made at speeds of 25 and 50 fps (Scale equivalent of 50 and 100 fps respectively) with the modules suspended from an overhead track and accelerated through a cable and pulley system by a falling mass Results of the approximately 24 tests, some of which included deliberate yaw bias have been "generally successful" according to McDonnell engineers, although it appears that impact loads will be higher than first estimated for full scale Gemini craft

Gemini communications systems consist of redundant two way high frequency (HF) and ultra high-frequency (UHF) transmitters for voice, telemetry and command channels and C and S-band tracking beacons

UHF transmitters radiate over an extendable and retractable 16 ft antenna UHF transmitters broadcast over a stub antenna on the rendezvous and radar module during launch and re-entry During orbital flight UHF transmissions are made over a foldable antenna on the adapter module after re-entry when the adapter module has been jettisoned UHF transmissions are over a steel whip antenna deployed with the paraglider

S-band tracking beacon uses an annular slot array antenna on the adapter C-band beacon uses three helical antennas in cavities on the adapter module and an annular slot array antenna

Gemini manufacturing line is divided into five sub-production lines—rendezvous and radar module re-entry control system module cabin (including the manned pressure hull), large pressure bulkhead, and the adapter module

Each structure is separately manufactured on individual lines on the plant floor and is fitted with systems in separate areas within the super clean assembly white room at one end of the floor All modules come together, like spurs on a main line, within the white room and are in a flight-certified condition Virtue of this tree-shaped manufacturing plan according to McDonnell, is that it allows the company to back up on a finished module and make changes without seriously disrupting other modules of the spacecraft

On the plant floor, the module structures are mounted on pigs only for major manufacturing processes, such as welding They then are placed on mobile frames, or clean up dollies, for riveting and bolting operations

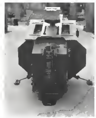
At present there are five Gemini spacecraft on the plant floor Three are flight vehicles and two are static articles, which are flight-rated spacecraft intended for ground testing Manufacturing cycle from start to delivery of a flight-ready spacecraft presently is estimated to be from six months to eight months

Testing has been integrated into the manufacture of Gemini There are four phases of testing based on the building block concept

- Phase 1 is those tests conducted on individual electronic packages and delivered systems to ascertain that these packages and systems meet contractual specifications
- Phase 2 is the testing of each individual system, such as the guidance system, independent of any other, with the exception of electrical power Systems will be installed in their proper modules. Wherever a system is distributed through two or more modules simulators in rack consoles will duplicate the response of the missing part(s) These tests will identify the low, average and high points of each system's operating characteristics so that later deviations can be evaluated against known parameters
- Phase 3 is those tests of systems operating under simulated environments, including vibration, both random and booster associated, and low-pressure altitudes Spacecraft, with an internal pressure of 5 1 psi, will be placed in one of two vacuum chambers which will be pumped down to at least the equivalent of 185,000 ft Also included in this test category are the firings of all thrusters in the OAMS and re-entry control systems
- Phase 4 tests are simulated missions for every possible flight regime, from a normal launch to landing to an abort on the pad Tests will be conducted in real time only where there is a sequential series of events such as the imitation of abort-escape of the ejection seats through deployment of the pilots' parachutes Coast periods, where no major sequences occur, will be bypassed

Phase 2 and 4 tests, the major categories, will be conducted in a special 18 ft tall, 60 x 30-ft, screen room being built by McDonnell as an adjunct to the white room All six sides of the room will be grounded to preclude spurious signals

This room will be able to accommodate three spacecraft simultaneously All instrumentation and test cables will enter the room through a central junction box and closed-circuit television will provide test conductors with visual



QUARTER-SCALE MODELS of the Gemini have been used to test landing skid system on different surfaces Mass on plate at top of model is adjustable to induce yaw bias

Dr Herb (E H) Phelps got his BChE from Clarkson College of Technology and his MS and PhD from Case Institute of Technology. He joined USS in 1955 after three years in corrosion work at Wright Air Development Center. He is a member of the National Association of Corrosion Engineers and the Electrochemical Society.

Atmospheric stress-corrosion tests of bent beam alloy and stainless steel specimens offer a guide to specification of steels for aircraft and missile uses. The microstructural characteristics of stress corrosion are investigated in several USS research projects.

"In the design of ground support equipment, critical days or months can be lost solving problems which may already have been solved for you . . . that's why you should come to U.S. Steel with your corrosion problems"

—*Herb Phelps, Division Chief, Corrosion Technology Division, Applied Research Laboratory, U S Steel Corporation*

"Corrosion losses in the United States amount to about $7 billion every year, and here in our Applied Research Laboratory at Monroeville, Pa. we're doing something about it," says Herb Phelps. "In fact, we're doing substantially more than anyone else in the industry.

The story of our corrosion program goes back to March 1 1929. That was before my time, but the steel that resulted from the first program—USS COR-TEN High Strength Low Alloy Steel—is still more in demand than any other high strength, corrosion-resistant steel on the market. When COR-TEN Steel was introduced, our tests enabled us to show that it had 4 to 6 times more resistance to atmospheric corrosion than carbon steel had. This ratio has been fully substantiated by later testing programs that have also developed atmospheric corrosion data for hundreds of other experimental compositions.

"Since 1929 we've exposed over 64,000 samples of steel in corrosion tests, some of them for as long as 30 years.

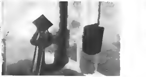
"Today, we literally have acres of test racks around the country exposing samples of every steel used in metal-working to rural, industrial and coastal atmospheres. We have hundreds of samples built into structures inserted in pipelines and vessels used by dozens of processing industries and during the winter months we even expose samples underneath the front bumpers of about 70 automobiles to determine the effects of road salts.

"But that's only part of the story. Here at the Applied Research Laboratory, we have a full time crew of 28 technicians who complete over 100 test programs every year on applications for steel products. We're trying to find out the cause of stress corrosion for example, and how proper design and special treatments can prevent it. We investigate things as mundane as the corrosion of stainless steels by dairy cleaning compounds and as exotic as corrosion erosion of sensitized stainless in a thorium dioxide uranium trioxide slurry which is the rather high-sounding name for a certain type of fuel and coolant for a nuclear reactor power plant.

"I think you'll agree that if you have a corrosion problem we're the people to see. We often investigate customer corrosion problems in the field. If you have a corrosion problem and want our help call the USS Office nearest you—or write to United States Steel, Room 6718, 525 Wm Penn Place, Pittsburgh 30, Pa. USS and COR-TEN are registered trademarks.

USS United States Steel

Corrosion test installation at Harbor Island, North Carolina. The importance of sea water testing is emphasized by U. S. Navy statistics that point out that every $1 spent to prevent corrosion on ships ultimately saves $30.



Research into the mechanisms of corrosion is an important part of United States Steel's corrosion program. This device, a potentiostat, measures the current required to maintain a constant potential in the electrochemical processes of corrosion.

access to the room without equipment moving the effectiveness of the screen. There will be two stations of test equipment which will take Phase 2 data off three spacecraft at the same time. For Phase 4 tests, however, the stations will be able to accommodate only one spacecraft each.

Major test tool is the Compatibility Test Unit (CTU), a non-flyable Gemini. It is functionally complete, containing all systems, but it lacks such items as hatches, couches and propellants. Primarily, it is a unit to test the compatibility of all electronics aboard the spacecraft. Once this task is done, its major purpose will be fulfilled. However, it will be kept as a tool on which proposed changes can first be verified before incorporating them into the spacecraft's design.

Test Points

Gemini is built with special test points on each package and circuit so that no flight connections are broken for test purposes. On Mercury, flight connections had to be broken to accept test equipment leads and after completion of tests, had to be reconnected. Gemini test points are in parallel with the unit being tested and this approach is expected to reap the advantages of increased reliability.

Test procedures on Gemini also have been closely correlated with the design of test equipment; this lack of coordination was a serious failing of the Mercury program, according to McDonnell.

The company punches each test procedure on an IBM card, copies of which are sent to NASA's Manned Spacecraft Center, Houston, Tex., and the center's preflight operations branch at Cape Canaveral, Fla. Coupled with identical test equipment at the factory and the launch site, this should guarantee that anomalies discovered during checkout are attributable to the system under test and not the test process itself.

McDonnell recently signed a $456,650,062 contract with NASA for the manufacture of 13 flight rated Gemini spacecraft, 16 adapter modules, nine Agena docking adapters, one docking simulator trainer, five boilerplate capsules and three static ground test spacecraft.

McDonnell presently has about 4,500 personnel assigned to the project and expects to increase this figure to about 5,300 by the end of this year.

Expandable Space Shelters Developed

Self-expanding space shelter and solar collector which can be packed in a one ft sq container and later expanded into a 7 ft high, 7 ft-dia rigid structure, has been developed by Air Force Aeronautical Systems Div at Wright-Patterson AFB. Shelter will be made of a highly-expandable honeycomb core material called "AlFor" developed by ASD scientists. Drawing shows a spaceman entering one of the air tight shelters. Second shelter is shown expanding in background. Shelters expand in a vacuum without being inflated. Geophysics Company of America has been awarded a $108,000 ASD contract to build the structures.

Single-Gas Environment Choice Debated

By Barry Miller

Los Angeles—Conflicting viewpoints over use of a single-gas environment for the Gemini and Apollo spacecraft were debated here recently during a panel session at the 34th annual Scientific Meeting of the Aerospace Medical Assn.

Panel was convened to discuss questions and doubts which have arisen over choice of a 100% oxygen, 5-psi cabin environment (AW Feb. 25, p. 79) for the two manned spacecraft.

Controversy centers on whether exposure for long periods of time to a 100% oxygen environment, pressurized to a third of an atmosphere (5 psi.), can harm astronauts. Both critics and defenders of the single gas system generally agree that there is no demonstrable evidence of physiological problems which would prevent successful human performance in the all-oxygen system during spacecraft missions up to two weeks in duration.

However, both factions also agree that presently unexplained and minor hematological changes, vision impairment and abnormal urinary effects found in test subjects could become more significant in missions longer than those contemplated for Apollo and Gemini. Such advanced missions would include those for space stations and lunar bases.

Critics of the single-gas system argue that just as mission durations of Mercury were extended beyond original expectations, so too, may those of Gemini or Apollo. In this event physiological data gathered in Gemini atmospheric validation tests which do not suggest disabling hazards for a 14-day mission, would no longer necessarily be applicable.

Defenders of the single-gas system, whose viewpoint was summarized by Lt. Col. Stanley C. White, USAF (MC) of National Aeronautics and Space Administration's Manned Spacecraft Center, cited these reasons for choosing it:

- **Extra-vehicular operation**—Single-gas system would minimize the danger of bends and eliminate the need to denitrogenate in reduction of suit pressure when an astronaut has to leave the capsule in space.
- **Less complexity**—Single-gas system would be less complex than a mixed-gas system and consequently would be more reliable. The two-gas system requires more regulation and monitoring. The complexity adds weight and volume to the mixed-gas system.
- **Leak rates**—These would be lower in the single gas system. If a leak does occur in the mixed-gas system, the pressure change could introduce bends.

In response, critics of the single-gas choice pointed out that a mixed-gas environment has been man's natural environment for thousands of years and that to put him into a 100% oxygen system introduces another variable into the unknowns he will encounter in space. They maintain that simultaneously with the commitment to the single-gas system, a parallel effort should be directed at developing a suitable mixed-gas system. Then, should physiological hazards to man on long term exposure in the all-oxygen environment be revealed in further tests, which all parties to the controversy agree are necessary, a backup or alternate system would be available.

Lt. Col. Rufus R. Hessberg, Jr., USAF (MC), who advocated a search for a mixed-gas backup system, stressed importance of visual problems, noted in tests conducted by Air Crew Equipment Laboratory and Aviation Medical Acceleration Laboratory, one of a series of NASA-supported atmospheric validation experiments. These revealed changes in peripheral vision during night adaptation after subjects were returned to sea level from test atmosphere.

Hessberg emphasized the role of visual acuity in space, particularly in the docking maneuver. If 100% oxygen impairs vision, he observed, then it is time to seek a system using an inert gas such as man has on earth. The role of nitrogen in man's physical well-being needs further investigation, he said.

Another possible drawback to the single-gas system cited by both critics and defenders of that type system is that of atelectasis, a partial collapse of the lung, a condition observed in pilots supported by single-gas and exposed to high acceleration. It has not been observed in those exposed to a mixed-gas system, according to Dr. James N. Waggoner, medical director of Garrett Corp.

An effort was made in one of the three validation tests at ACEL-AMAL to test for atelectasis under continuous exposure to pure oxygen at decreased pressure. Atelectasis was not observed under the test conditions. A program is under way at Garrett in cooperation with the University of Southern California to study single gas and acceleration re-entry g forces.

Another point of contention centered on the nature and meaning of the physical hazard of fire in the single-gas system. Ignition temperature is reduced and the speed of burning increased in the pure oxygen 5-psi system, panel and audience participants agreed. In two of the three Gemini validation tests, those conducted at ACEL-AMAL and

Titan 2 Erectar Tested at Cape

Erector to lift Martin Titan 2 vehicle into position to launch the Gemini two-man spacecraft has been installed and tested at Cape Canaveral, Fla. The 140-ton erector also will serve as work platform for preparation of Titan 2/Gemini prior to launch. Erector contains "white room" at top to protect spacecraft from outside environmental contamination.

Brooks AFB fires broke out causing injuries requiring hospitalization In the ACEL case, one fire occurred when a subject attempted to remove a burned out light bulb with a towel

But, White and others argued, the inclusion of an inert gas does not eliminate fire hazards, any life maintaining system will support combustion and any fire, regardless of rate and intensity, in a life supporting environment is catastrophic The danger will have to be reduced through careful design

A fire in a 100% oxygen, 5 psi system, an ACEL scientist pointed out, cannot be smothered as an ordinary fire can, but will only be stopped when all oxygen is removed from the chamber

In outlining additional requirements of a mixed gas system over these presently required for a single-gas system, Waggoner supplied interesting figures which also may provide clues about size of the Apollo environmental control system which his company is building for NASA The mixed gas system, he said, would necessitate

- **Additional weight** of 52 lb, an increase of about 10% over the 100% oxygen, 5-psi environmental control system
- **Addition of 1 1 cu ft,** within the vehicle, an increase of 8%
- **Nine additional parts,** including two oxygen control valves nitrogen storage sensor, shut-off valve, and partial pressure sensor An additional control sensor would also be necessary, but this could be evolved from the spacecraft's fuel cell

Frank Voris, who is responsible for human research in the Office of Advanced Research and Technology at NASA, suggested possibility that radiation limits may be cut down by a 100% oxygen system For long term flights, the inert gases must be used to help the oxygen system

He reported OART is studying various life-support systems including a chemical system which will support five men for 30 days at sea level atmosphere and a 720 man-day system (four men for 180 days) Such systems are unlikely for Apollo, but may be scheduled for later Gemini and Apollo missions

Manned Spacecraft Center also is reported to be letting a series of study contracts for further examinations of 100% oxygen and mixed-gas systems These are expected to be awarded to a DOD agency

Possible long-term effects of short duration exposure to pure oxygen at reduced pressures, which resulted in the unexplained hemotalogical and renal abnormalities are still unknown, it was pointed out Tests by Republic Aviation on the pure oxygen system, conducted at four pressure levels (3 8, 5, 7 4 and 14 7 psi) in which the unexplained hemotalogical and urinary findings turned up, were completed in recent months

In concluding his talk earlier in the day, Edward Michel who heads life support section in the crew systems division at MSC pointed out that "within rather broad limits, either [pure oxygen or two-gas atmospheres] can be acceptable but it has not been demonstrated that either is preferable If, for long duration missions, a two-gas atmosphere were selected it is still probable that pure oxygen would be the backup or emergency mode This is the rationale for the continuing interest in pure oxygen atmospheres"

Biomedical Recorder for Gemini

Seven-channel biomedical magnetic tape recorder weighing about 3 lb will be used to record medical information from astronauts on Gemini spacecraft flights Two of the recorders, developed by the Cook Electric Co , Morton Grove, Ill , will be used to register data continuously for up to 90 hr , utilizing two extra tape reels on each recorder.

New generation of Shaped-Beam Tubes makes advanced techniques possible in data display

by A. H. Wisdom
Manager of Research and
Engineering for Data Products

CHARACTRON® Shaped Beam Tubes produced nearly 10 years ago, many of which are still being used in the display consoles of the SAGE program, have achieved 20,000 hours or more of reliable performance. Today's CHARACTRON Tube represents a new generation of development, offering dozens of major improvements over the original tube. The principle, however, remains essentially the same.

HOW IT WORKS

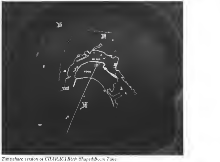
Heart of the CHARACTRON Shaped Beam Tube is the stencil-like matrix, a thin disc with alphanumeric and symbolic characters etched through it. This matrix is placed within the neck of the tube in front of an electron gun. The stream of electrons emitted from the gun is extruded through a selected character in the matrix. When the beam impinges on the phosphor coated face of the tube, the character is reproduced.

The standard matrix carries 64 characters. However, matrices have been made with 88, 128, and 132 characters. Coupled with new variable character size capabilities, the CHARACTRON Tube offers a wide latitude in symbol generation. The beam is passed through one of the characters by applying the proper voltage to the selection plates. Electrostatic reference plates and/or magnetic deflection are then used to position the beam at any tube face location. In more compact tubes, the entire matrix is flooded with electrons generating a complete array of characters, while only the desired character is allowed to pass through a small masking aperture. A small diameter beam can be used to display data from analog inputs simultaneously with the characters.

NEW GENERATION OF TUBES

Today's CHARACTRON Tube is *not* the same tube built ten years ago. While all major improvements cannot be discussed, following are some of the more significant.

Earlier tubes had some deformation of the characters at the screen edge. The modern tube is sharp to the edge, with much greater resolution. New bright phosphors have been developed including a pastel green which eliminates spot size variation or "blooming". When necessary, tube length can now be dramatically decreased. A tube 25 in. long now achieves the same results once requiring a tube 45 in. long.



Time-share version of CHARACTRON Shaped-Beam Tube

SPEED

Many optimistic goals have been claimed regarding the speed of character writing tubes. Frequently, however, these claims do not delineate the time required for the positioning of these generated characters but simply state the time necessary for generation. It is a simple matter to blink a character at tremendous speeds at the same place on the tube face. Generating different characters and positioning them in different places on the tube is something else. The shaped beam principle generates characters in a period of time independent of the complexity of the character. Complex symbols can be generated as simply as a dot. With high speed circuitry, selection can be accomplished at rates equivalent to oscilloscope deflection frequencies.

For example, characters could easily be generated at a million each second. However, today's magnetic deflection yokes require a minimum 5 to 8 microseconds to settle the magnetic domain in the core and this is the limiting factor in positioning speeds. Using a high speed selection system and allowing five to ten microseconds for unblanking, CHARACTRON Tubes can provide realistic writing rates of 50,000 characters per second or more, even using random deflection. Electrostatic deflection tubes now under development promise writing speeds of up to 200,000 characters per second.

ECONOMICS

A CHARACTRON Tube by itself appears to be relatively expensive, but a system using this tube can economically justify itself easily. This is true because the CHARACTRON Tube replaces both the necessary character generator and much of the circuitry required by other systems.

In recent models, alignment procedures have been simplified, and the tube holds alignment longer than other character writing systems. A CHARACTRON Tube can be set up by an experienced man in less than one hour. Tubes are available in a wide range of phosphors with practically any desired color or degree of persistence. Resolution of 1800 TV lines can be provided, the only limitation being the grain size of the phosphor. CHARACTRON Tubes are no more fragile than any other cathode ray tube. They have been exposed to a 32G shock for 52 milliseconds without harm and can take just about any shock that does not fracture the glass. In one application, the tube was used in a portable battlefield display console.

PICTURE WINDOW TUBE

Frequently, it is necessary to continuously repeat certain data on the face of a tube while changing other data.

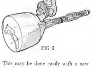


FIG I

This may be done easily with a new development called the "picture window" concept. In the "window" tube, changing data from computer, radar, or communications link, is presented in the usual manner. Repetitious data are projected through the "window" onto the faceplate using a slide or film projector (Figure I). In a typical application, a geographic map of the area is projected on the face while the computer presents changing data. As the area under surveillance changes, the operator pushes a button to select another map. In another application, business or engineering forms are projected on the tube and filled in with data from the computer. Included in this option is a recording camera. By means of a beam splitting half silvered mirror, the camera maintains optical access to the entire tube face. A button actuated solenoid operates the camera, recording all data being displayed.

TIME-SHARE TUBE

A new "time-share" version of the tube produces alphanumeric data and at the same time performs beam writing to draw curves and vectors. In the drawing mode, electrons pass through a special large aperture so that none of the beam is blocked. Brighter beam drawings result. The name "time share" is derived from the fact that both the alphanumeric and drawing mode share the beam from one cathode for part of the time. This tube is ideal for applications such as long range radar when the antenna may turn at a relatively low speed of six times a minute.

TWO-GUN TUBE

On short range radar requiring high rotation speeds of perhaps 25 times a minute and many hits on small targets to build up an image, there may not be enough time left for forming alphanumeric symbols. With these applications, a two gun tube (Figure II) is suggested. This tube retains the beam shaping electron gun for producing characters and employs another gun to accomplish the video writing. This second gun, when coupled with video driving circuitry, can be used to generate high resolution TV images including scan converter readout or

FIG II

raw radar data. These images, of course, can occur at the same time as and without any effect on the alphanumeric data supplied from the shaped beam gun.

SYSTEMS

In addition to offering the CHARACTRON Tube as a display or recording character generator, General Dynamics|Electronics has a number of custom and standard display, printing and film recording systems which utilize the tube.

Custom installations include direct view consoles as well as film recorders which automatically process and project large-screen displays for group viewing.

The S-C 1090 Display console (Figure III) presents alphanumeric, symbolic and graphic data from computers

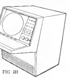


FIG III

or other sources. It is a complete, "off-the-shelf" display unit. Optional equipment includes internal test routine, input register, level converters, internal storage of complete display frame, vector generator, expansion and off-centering, category selection and various data channel buffers. The console is 66 in. long, 32½ in. wide, and 47 in. high. It is recommended for a variety of applications, including command and control systems, air traffic control, computer readout and data display for any automated process.

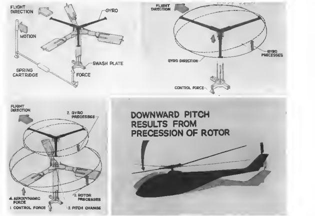
The S-C 1020 records the output of large scale computers on film and/or paper at equivalent speeds. Combinations of drawings and alphanumeric data may be recorded in fractions of a second.

The S-C 3070 provides high speed asynchronous printing without impact on paper for communications or computer output applications.

WRITE FOR MORE INFORMATION

For technical information on the S-C 1090 Display, the S-C 1020 Computer Recorder, the S-C 3070 Electronic Printers or the new generation of CHARACTRON Shaped-Beam Tubes, write to General Dynamics|Electronics, Department D-28, P. O. Box 127, San Diego 12, California.

GENERAL DYNAMICS | ELECTRONICS GD SAN DIEGO



CONTROL SYSTEM of Lockheed XH-51A helicopter uses gyro precession, initiated by stick force applied through a swashplate, to produce pitch changes in the rotor blades. Sequence diagrams show how system produces nose-down pitch.

XH-51A Reaches 160 mph. in Flight Tests

First two Lockheed XH-51A rigid rotor helicopters have logged about 20 flight hours during the first four months of their flight-test program and have demonstrated speed capability up to 160 mph.

Autorotations, fuel cuts during hovering, and tailoring and evaluation of stability and control also have been performed during this third phase of the company's program funded jointly by Army and Navy.

First and second phases of the program—wind tunnel tests of a full-scale rotor system, and the design and construction of two research aircraft—have been completed.

First detailed report of the XH-51A program was presented at the 19th annual national forum of the American Helicopter Society in Washington by W. H. Statler, R. R. Heppe and E. S. Cruz of Lockheed-California Co.

Lockheed's XH-51A is a sleek-looking helicopter in the 3,500-lb. weight class, powered by a single Canadian Pratt & Whitney PT6A turboshaft engine rated at 500 shp. It drives a three-bladed rigid rotor with a 35-ft. diameter and 13.5-in. blade chord.

Over-all length of the helicopter with the rotor operating is 41 ft., and its maximum height is 8 ft. 1 in. Tail rotor has a 5.5-ft. diameter, is two-bladed with a high solidity ratio to keep the fuselage length short and to provide the necessary thrust for high-speed flight. The vertical tail surface that mounts the rotor is cambered to unload the tail rotor in high-speed flight.

Fixed horizontal tail is used to balance the pitching moment from the fuselage.

Main rotor blades, produced by Parsons Corp., have a symmetrical NASA 0012 airfoil section and a 4-deg. linear twist from root to tip. Blades are made of stainless steel and aluminum bonded-honeycomb construction. Tail rotor blades also have NASA 0012 airfoil section, 4-deg. twist, and are made entirely of stainless steel.

The XH-51A program grew out of investigations begun by Lockheed in 1959, covering a wide range of VTOL vehicles for short range, moderate speed applications. The company's analyses showed that there wasn't any obvious candidate to beat rotary-wing aircraft in hovering, but contemporary rotary-wing vehicles didn't meet the rest of the company requirements.

At this point, Lockheed rediscovered the rigid-rotor system, which had appeared off and on during the several decades of autogyro, convertiplane and helicopter development. The designers synthesized a rotor system that featured cantilevered blades with freedom only around the feathering axis. To these they added a mechanical stabilizing gyro between the blades and the pilot's controls, and a control system that used a spring cartridge between the stick and the control gyro to get the mechanical motion and force characteristics they wanted.

As pointed out by AVIATION WEEK & SPACE TECHNOLOGY last year (Jan. 29, 1962, p. 27) the unique contribution of the Lockheed design is in the stabilizing and control system, and not in the rotor. The system is built around a gyro in the form of a three-bar rotating assembly mounted above the rotor. The gyro is connected to the pitch-change mechanisms on the blades on one side, and through a swashplate to the control stick on the other.

If the pilot commands a nose-down pitch of the aircraft he moves the stick forward. This applies a force in a lateral plane to the swashplate (see illustrations). The gyro responds by precessing its plane in a nose-down direction, the rotor angle between the gyro plane and rotor plane changes and this causes the cyclic pitch changes in the rotor. Aerodynamic forces on the rotor precess its plane in a nose-down direction, and because the rotors are rigidly attached to the mast, which in turn is rigidly attached to the fuselage structure, the fuselage pitches nose-down.

Lockheed designed, built and flew a test vehicle, the CL-475, which strengthened the designers' belief in the control system and proved system feasibility both mechanically and structurally.

U. S. Navy and Army awarded Lockheed a research contract in February 1962, to investigate three major areas of the new helicopter design:

- **Stability, control and handling** qualities of the rigid rotor system aimed at an ultimate objective of a 175-kt. (202 mph.) speed.
- **Vibration characteristics** of the system over that speed range.
- **Stresses and loads** on all dynamic components, measured and analyzed over the speed range and for all normal flying operations.

Terms of the research contract covered the XH-51A from basic analysis through flight test. Lockheed was to design hardware, carry through full-scale wind-tunnel tests, build two flight test aircraft, and test them in flight. As defined, the program listed three phases:

- **Design, manufacture** and test of a full-scale rotor system with simulation of fuselage inertia and aerodynamic characteristics. This work was done in cooperation with the Ames Research Center of the National Aeronautics and Space Administration. Tests were made in the 40 by 80 ft. tunnel at Ames.
- **Design and manufacture** of two research aircraft, performing enough static and fatigue testing to establish the necessary life of the dynamic components for the intended flight program.
- **Flight research and testing** of the two vehicles through their operating envelope. Currently the flight-test program is four months old, both helicopters are flying and they have logged over 40 flights.

Major design objective in the program was the reduction of drag to meet high-speed requirements. Drag goal was an equivalent flat plate area of five square feet, which Lockheed claims is considerably below comparable conventional helicopters. Aerodynamic lines of the fuselage and the use of a completely retractable landing gear made major contributions to the overall low drag coefficient of the helicopter.

External skins were flush-riveted, and fuselage compartments were sealed to minimize airflow disturbance. Rotor plane was tilted forward six degrees with respect to the fuselage vertical reference line to get an optimum balance between fuselage attitudes during hovering and high-speed flight.

Lockheed XH-51A Weight Summary

Rotor group	441 lb.
Tail group	96 lb.
Body group	415 lb.
Landing gear	110 lb.
Flight controls	223 lb.
Engine section	12 lb.
Propulsion group	611 lb.
Instruments	28 lb.
Electrical group	90 lb.
Avionics	12 lb.
Furnishings and equipment	92 lb.
Weight empty	2,130 lb.
Pilot and co-pilot	400 lb.
Oil and unusable fuel	40 lb.
Fuel	530 lb.
Payload	400 lb.
Design gross weight	3,500 lb.

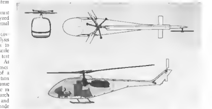
Control swashplate was mounted at the base of the transmission inside the fuselage, and the control rods were brought through the main rotor shaft to the gyro. The gyro itself, three bars visible in the three-view drawing on this page, was mounted as close to the rotor plane as possible to reduce the frontal area. Main rotor shaft was enclosed in a fairing to minimize the drag.

Lockheed emphasizes that the objective was not to produce solely a high-speed helicopter. Fuel for three-hours endurance is aboard, and ranges extend up to 300 naut. mi. Optimum cruise speed is 140 kt. (161 mph.). Design objective for hovering performance was to meet the Army's hot-day condition of hovering out of ground effect at full gross weight at 6,000 ft. altitude on a 95F day.

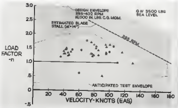
Capability to vary the stability and control parameters was designed into the XH-51A aircraft so that optimum characteristics could be developed. Stability variation is handled by changing the inertia of the control gyro. Stick force gradients, control sensitivity and other control parameters are changed by altering the control boost ratio. Mechanical advantages of both the control stick and the control gyro can be varied to change control characteristics.

Power required and available curves for the XH-51A, the standard way of predicting performance, show a maximum level speed of about 160 kt. (185 mph.). To reach the design speed of 175 kt. will require a slight dive angle, Lockheed says. Speed for maximum range is 140 kt. (161 mph.). For maximum endurance it is 75 kt. (87 mph.).

Goal of the Ames tests was to obtain data on blade stresses and bending



INBOARD PROFILE of XH-51A shows arrangement of internal details, top view shows three-bar gyro used to operate pitch change mechanism of rotor blades.



ANTICIPATED TEST ENVELOPE for XH-51A is shown in dash lines on V-n diagram; test points shown have been established during early flights.

moments early enough in the program to be of significant aid to the designers of the test vehicles. Stability and control investigations were part of the planned program, and rotor parameters were to be varied.

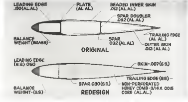
Mount system had five degrees of freedom, it carried an inertia frame which simulated fuselage inertia under loading conditions, and was covered by a body shell aerodynamically similar to the final proposed XH-51A layout.

Whirl tests were made before the model went into the tunnel and developed lift values equal to 1.72g and body moments equivalent to an 8-in. offset of the center of gravity.

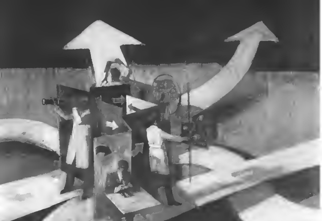
But during the initial tests in the tunnel, a blade failed at an equivalent forward speed of 75 kt. and badly damaged the rotor system and some of the airframe shell. Detective work traced the trouble to partial bonding of the blades during manufacture. Lockheed emphasizes the failure was not related to the rigid-rotor concept but was strictly due to faulty manufacturing procedures.

Five months later, a new blade design had been completed and built and the test vehicle went into the Ames tunnel again. Results of the tests showed:

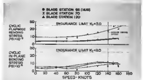
- **Control power** approximating seven to 10 times that of a conventional teetering or hinged rotor.
- **Cyclic stress increased** with forward speed as predicted but remained below the endurance limit for infinite life at the maximum speed of 160 kt.
- **Cyclic stresses were highest** in flapping at the hub, and inplane bending stresses were relatively low and reasonably insensitive to forward speed.
- **Cyclic flapping stresses** were somewhat higher than predicted, and inplane bending stresses were somewhat lower.
- **Vibration levels** were significantly lower than either target values or the requirements of military specification H-8501A. Only significant vibration frequency was the 3P mode, which does



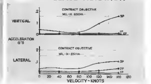
BLADE DESIGN was changed after failure in wind tunnel tests; original design (above) was replaced by honeycomb-filled blade layout (below).



BLADE BENDING STRESS

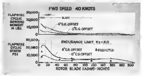


FUSELAGE VIBRATION

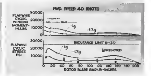


BLADE BENDING STRESSES were measured in extensive wind-tunnel tests (full curves, left) and compared with flight test data (separate points). Fuselage vibration data (right) was established from early flight tests.

OFFSET C.G. EFFECT ON LOADS AND STRESSES



EFFECT OF LIFT ON LOADS AND STRESSES



OFFSET CENTER-OF-GRAVITY and lift effects on loads and stresses in the rotor blades were determined during wind tunnel tests at NASA's Ames Research Center Predicted values were generally confirmed by test curves.

not begin to rise until forward speeds exceed 100 mph At top test speed, the 3P vibration level meets the military specification and is below contract objectives

Soft tooling was used to build the two aircraft to keep the program cost low Basic airframe structural techniques were used on the fuselage.

Hub construction is novel; it features three laminations in vertical layering Lockheed chose this unusual design form so that the hub would have structural redundancy

Main transmission, built to Lockheed design by the Steel Products Engineering Div of Kelsey-Hayes, weighs 248 lb and transmits the full engine horsepower through a gear reduction of 17 5 1 using a single bevel gear set and two planetary sets.

Bench testing of the unit was run over a range of engine powers from 450 to 500 shp while taking up to 120 shp off the tail-rotor gears At the same time the mast was loaded with rotor thrust up to 2g and bending moments up to ±120,000 in./lb., equivalent to a 34 in offset of the center of gravity

Whirl tests at Lockheed further tested the complete rotor assembly from the Ames tests Additional dynamic loads were added Tests covered rotor lifts up to 7,000 lb (twice the gross weight), all rotor speeds including overspeed at 405 rpm., and powers up to 580 hp Full c g offset and rotor bending moments, simulating those of a side-hill or one-skid landing, were thrown into the test program Bending moments up to 63,000 in./lb were imposed More than 800 starts and stops were made during the tests

Fatigue testing was done on a section of the main hub and a 5-ft span of the blade root Load spectrum was determined from the Ames tests, and greatly exceeded the estimated cycling that the blade would get during the flight-test program

Tail rotor system including its gearbox, drive shaft and intermediate gearbox was run for 100 hr using maximum rotor power, blade angles and overspeeds

Entire helicopter structure was static-tested with duplication of air loads, tail rotor maximum thrust, side-hill landings and even complete jamming of the transmission

Tie-down tests, which lasted for 25 hr of varying power and loading conditions, followed These were completed last September, and the first vehicle was dismantled for complete inspection before its first flight

Major concern in the early portion of the flight-test program has been with evaluation in the flight envelope and determination of stability and handling characteristics Major points from the program include

- **Autorotations** Pilots have made the transition from forward flight into autorotation smoothly without any measurable drop in rotor revolutions per minute Rate of descent has been as low as 1,300 ft./min. at a glide speed of 60 kt
- **Power failures in hover** These were simulated by cutting off fuel during hovering with a skid height 5 ft above the ground Rotor responses and sink rate were easily controlled, says Lockheed, and landings were excellent
- **Cyclic stick forces.** Helicopter meets the MIL-H-8501A specifications of 2 lb./in. of stick travel, but pilots who have flown the XH-51A prefer higher forces because of the high damping and inherent stability, Lockheed reports Both aircraft currently are flying with 5 lb./in. of travel in pitch and half that in roll
- **Static stability.** Longitudinal static stability is positive over the speed range

explored [illegible] stability has not been evaluated in detail, but appears to be high.

• **Dynamic stability.** Vehicle motion is essentially dead-beat and it requires less than one second to damp completely following either longitudinal or lateral disturbance. Dutch roll mode is well damped.

• **Response to control deflections.** Control sensitivity is good about all axes and response is well above the military specifications. During hover, a 1-in. control displacement in pitch produces a pitch rate of 10 deg./sec. for both forward and aft control displacement, reaching that maximum rate about 0.8 sec. after control actuation. In roll the rate is 13 deg./sec./in. of cyclic control displacement, with a time lag of about 0.7 sec. Yaw velocity of 100 deg./sec./in. of pedal displacement results from pedal use during hover.

• **Measured blade loads.** These agree well with wind tunnel data, showing somewhat lower cyclic span-wise bending moments in flight than in the tunnel, but the distribution along the span follows the trend of the tunnel tests. Cyclic chord-wise stress variation shows similar trends, with the wind tunnel test runs having conservative values.

• **Vibration characteristics.** First flights showed higher vertical vibration accelerations in one frequency range than had been anticipated. Blade and hub modifications have been investigated to raise or lower the natural frequency in this mode, and have produced some significant reductions in vibration.

PRODUCTION BRIEFING

Grumman Aircraft Engineering Corp. and Alderson Research Laboratory have signed an agreement for collaboration in production of instrumented anthropomorphic dummies for use in human survivability tests of aerospace vehicles. The companies have developed a flesh-textured dummy with a 12-channel instrumentation package as their first joint product.

General Dynamics/Pomona has received a $5-million follow-on contract from the Navy for production of Terrier and Tartar surface-to-air missiles.

North American Aviation's Autonetics Div. will supply components and associated equipment for armament control systems for the F-104J Starfighter under a $9-million order from Mitsubishi International Corp. of Japan.

Electro-Optical Systems, Inc., Pasadena, Calif., will develop an altitude environmental measurement system under a $43,000 contract from NASA's Marshall Space Flight Center. System will be used to measure pressure, density, temperature and winds during boost phase of large space vehicles.

Garrett-AiResearch, Phoenix, Ariz., has received $2 million in follow-on contracts for production of cartridge-pneumatic jet engine starters for Boeing USAF KC-135 tanker aircraft.

Sprague Engineering Corp., Gardena, Calif., has received $1,075,570 in contracts from Navy for electrical power units for use with ground support equipment for naval aircraft.

Bendix Corp., North Hollywood, Calif., has received a $4-million contract for AN/AQS-10 dipping sonar systems to be installed in Navy's SH-3A (HSS-2) all-weather anti-submarine helicopters.

Mosler Safe Co., Hamilton, Ohio, will build vault-type doors and lock mechanisms for Minuteman underground launching silos under a $5.5-million contract from the Boeing Co.

Lear Siegler, Inc., will build automatic flight control systems for Air Force Ryan Q2C target drones under a $1,009,384 follow-on contract.

AFSC Systems Management Role Growing

By William H. Gregory

Air Force Systems Command is distributing its final report on the 40 specific recommendations that emerged from its Management Conference last year at Monterey, Calif. (AW May 14, p. 26), which dealt with the new environment for defense contractors.

One of the major recommendations—that of relieving top-level Defense Dept. and USAF headquarters of program details—reflects the growing dominance of AFSC in the systems management field with the decentralization of responsibilities by Headquarters USAF (AW Apr. 22, p. 33).

Roles of Systems Command and Headquarters USAF have undergone considerable study in the last year, the report said, and a constant objective has been to reduce the flow of program details from the command to higher levels. But the report also adds:

"The key to accomplishing this objective is the demonstration of enhanced technical validity and improved program management capability within AFSC."

One shift showing the changing relationship is in redline management procedures. These had provided for direct flow of program information and proposals from System Program directors in the field to management levels above AFSC for certain programs. Now they will be given thorough review at Systems Command headquarters before they are sent to high command levels.

Steps also are under way to achieve technical validity and to improve program management within Systems Command. These include:

- **Proposals and program change** review by a new AFSC Council headed by the vice commander and including senior headquarters officers as members. High level AFSC review is expected to reduce the need for detailed review at higher levels.
- **Continuous programming** is being instituted at Systems Command to avoid piecemeal, inconsistent recommendations to higher headquarters.
- **Program documentation,** not always adequately reviewed heretofore by Systems Command headquarters because of time limitations, will be given thorough review prior to submission to higher echelons.
- **Pressure is continuing** to improve cost estimates within Systems Command and to develop a strong cost analysis capability to support program proposals and annual budgetary submissions.

A steering group, headed by the USAF assistant vice chief of staff, is coordinating the USAF Headquarters decentralization decisions, and the Monterey report added:

"The charter specifies that one purpose of the steering group is to recommend procedures that are compatible with OSD [Office of the Secretary of Defense] practices. This compatibility will, in itself, have the effect of reducing the amount of detail to be forwarded to OSD, since utilization of OSD documentation concepts will permit summary data to be forwarded rather than detailed data."

In a related area of control, the conference had recommended that Systems Command redouble its efforts to gain full authority over the Advanced System Conceptual Study Program and to increase the scope and funding level of the planning effort.

Dept. of Defense, at the time of the conference, had suspended the program

Rolls-Royce Studies External Combustion Propulsion

Rolls-Royce is studying techniques of external combustion to propel aircraft at speeds of Mach 5 15 between 100,000 and 120,000 ft. Aircraft would use turbine engines for takeoff, climb and acceleration to Mach 5. Engines would then be shut down and thrust would be provided by burning fuel on the external surfaces. When fuel is injected at the wedge, combustion in the zone behind the after surface generates a pressure higher than that on the forward surface, giving a forward thrust.

for 14 months on the ground that it was not properly coordinated and was making excessive demands on technical manpower and resources.

New procedures and policies by Systems Command and clarification of industry participation has resulted in loosening of DOD restrictions and the Assistant Secretary of the Air Force (R&D) now has authority to release these funds, the report said.

Terming the progress in this area as excellent, the report said that autonomous Air Force control of more than half the total planning study effort for Fiscal 1964 had been established.

Two other conference recommendations dealt with the exchange of planning or technical information: one urging that new avenues be explored in the need-to-know exchange of planning data with industry through meetings and briefings.

The other was aimed at improving utilization of foreign technology, which may entail lifting of U. S. restrictions on disclosure.

Systems Command is revising its regulations on scientific meetings not only to improve their quality but also to conform to DOD instructions issued earlier this year. DOD requires that:

- **Purpose**, subject and list of non-defense personnel who will attend such meetings will be reviewed by the Secretary of Defense prior to any approach to non-defense personnel in cases when Air Force forward thinking is to be discussed.
- **Meetings** solely for exchange of information on the state-of-the-art in general scientific areas need not be reviewed if no Air Force forward thinking is involved.

Research and development cooperation with friendly nations overseas has been restricted by legislation, national policy and administrative interpretation. As one approach to the problem, Systems Command has asked USAF headquarters to review the disclosure policy. An investigation of possible changes is under way.

At the same time, steps have been taken within existing legislation and policy to improve international cooperation, including:

- **Documentation** in 15 applied research areas, which has been released to Britain by Systems Command under a diplomatic agreement type pioneered with Canada. In the case of Canada, this agreement has led to the USAF/Canada Defense Production/Development Sharing Program that gives Canadian sources the opportunity to compete for Air Force development and production contracts.
- **West German** potential for cooperative tasks has been surveyed by a Systems Command team specializing in aeronautical sciences.
- **Technical data** from the VTOL projects of three nations—the French Mirage 3V Balzac, the German VJ 101C, VJ101D and FW 1262 and the British P.1127—will be provided to USAF.
- **Potential for specific development** objectives has been discussed by Systems Command with the British Ministry of Defense and Defense Research Staff and working group meetings are planned for further exploration of the subject.

Some recommendations or proposals of the conference were partially accepted, were rejected, or were held to be met adequately by existing procedures.

One example was the recommendations for submission of separate technical and cost proposals so that technical judgments could be made on their own merits and thus combat tendencies to "buy" contracts with excessively low bids.

Systems Command tested three techniques to reach this objective. One, calling for concurrent submission but separate evaluation, is now approved for use by Systems Command procuring activities.

A second technique embodying the two-step method of submission of technical proposals first and cost proposals later was found best for medium to large dollar procurements where a small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The rotating Space Station Simulator shown here is only one of the many new facilities increasing Grumman's capabilities in the space field. Administered by Grumman's Space Sciences and Human Factors Group, the Simulator is yielding valuable information on the factors that affect man's tolerance of rotation—especially at velocities that exceed generally accepted limits. A program of continuing tests will help show how astronauts can live and perform in an artificial gravity environment. ■ Bioscience is just one facet of Grumman's expanding space studies, which include such basic disciplines as orbital mechanics, propulsion, guidance, structures, and reentry dynamics. Grumman is integrating and applying these disciplines into such long-range NASA programs as the OAO for Goddard Space Flight Center, and the LEM for the Manned Space Flight Center.
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number of potential sources exist. While the one-closing-date system will be preferred for small dollar R&D procurements, Systems Command is proposing a revision of Air Force Procurement Instruction 3 501 (b) (4) to permit the two step procedure to be used at the contracting officer's option.

The third technique, which calls for submission of cost proposals only by those contractors whose technical proposals are acceptable, offered a dubious advantage in cost proposal effort at the expense of acquisition lead time and would require granting of considerable latitude to procurement authorities to select contractors to submit cost proposals. Granting of such latitude was not feasible, the report said.

A second recommendation not fully accepted called for indication in requests for proposals of the weight factor assigned to such areas as technical, management, cost, logistics, past performance, etc.

To the extent that all factors that should be included in the contractor's proposal will, in the future, be included in proposal requests, Systems Command accepted the recommendation. Inclusion of the actual weights assigned to each factors was rejected, however, on the ground that the relative importance assigned to them by the contractor gives the evaluation group an insight into the contractor's understanding of the problem.

Cost sharing, an area of confusion to industry, is adequately covered by existing regulations, Systems Command believes, although the conference had recommended study of this area and possibly enunciation of new policy.

Besides the growing trend toward cost sharing, industry also expressed concern over lack of indication in requests for proposals as to whether cost sharing is to be considered. Armed Services Procurement regulations now specify that cost sharing is generally desirable in contracts with non-profit organizations. In R&D contracting with industry, ASPR require that cost sharing be considered by the contracting officer whether or not it is specifically mentioned in the RFP.

"Undeniably," the report said, "cost sharing can be a significant factor in determining the successful proposer, but the proposed arrangements must be evaluated in conjunction with other price or cost elements to determine the ultimate potential cost to the government. Needless to say, a technically inadequate proposal is not rendered acceptable by apparent economies associated with the cost proposal and/or proposed cost sharing."

Still another recommendation not fully accepted was one calling for indicating the funding available in requests for proposal and also the identification of sources being solicited.

Revealing such funding may not be reasonable, the report said, but indication of manhours involved is feasible and has been recommended for inclusion in ASPR. Identification of sources might discourage submission by a source which might in fact develop the best proposal, the report said, but in other cases might be advantageous to government and industry. The USAF's Armed Services Procurement Regulation Committee has been asked to study the question for inclusion in ASPR.

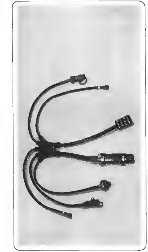
Fund release in contracting also was an area of industry complaint at Monterey, especially the technique of "spoon feeding" whereby contractors were paid in small increments—sometimes as an enforcement device. Since Monterey, the report said, there has been some indication that:

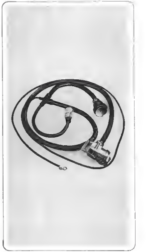
- **Defense Dept.** will release both program and funds in as timely a manner as possible.
- **Spoon feeding** can be eliminated to the extent that program approvals and funds are released in timely fashion by DOD.
- **Funds will no longer be withheld** as a control device in the ballistic missile programs since all production programs will be fully funded as of July 1, 1963.

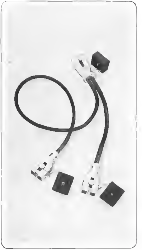
Airlines Report Officer Salaries, Holdings

Northwest Airlines Inc—**Donald W Nyrop** Director and President, $80 000 salary $5 728 expenses 10 000 shares of common stock **Frank C Judd** Vice President Maintenance and Engineering $33 000 salary $1 300 expenses 905 shares of common stock **Emory T Nunneley Jr** Vice President and General Counsel $18 000 salary $657 expenses, 500 shares of common stock **Paul Benscoter** Vice President Transportation Services $23 250 salary $1 018 expenses 100 shares of common stock **C L Stewart** Vice President-Economic Planning $20 428 salary $189 expenses 200 shares of common stock **A F Flaun** Vice President and Secretary $22 000 salary $650 expenses, 6 shares of common stock, **D H Hardesty** Vice President-Finance and Treasurer $23 500 salary $1 427 expenses 110 shares of common stock **M J Lapensky** Comptroller $20 875 salary $401 expenses **Dale Merrick** Vice President-Properties $18 000 salary $206 expenses 100 shares of common stock **R A Flerl** Vice President Personnel $20 875 salary $644 expenses 20 shares of common stock 2 shares of 5¼% preferred stock **William F Huskins Jr** Vice President Orient Region, $11 400 salary $5 012 bonus and indirect compensation $4 443 expenses 25 shares of common stock **R J Wright** Vice President-Sales $20 250 salary $2 273 expenses **F J Scott** Assistant Secretary (resigned 2/16/62) $2 565 salary **Croil Hunter** Chairman of the Board NWA $25 000 bonus and indirect compensation $1 037 expenses, 1 000 shares of common stock 1 000 shares of 5¼% preferred stock **James H Binger** Director $700 expenses 2 826 shares of common stock **Hadley Case**, Director $1 514 expenses 10 000 shares of common stock in the name of others 10 000 shares of 5¼% preferred stock in the name of others **Morton H Fry** Director $1 603 expenses 600 shares of common stock 9 000 shares of common stock in the name of others **Joseph T Johnson** Director $825 expenses 1 000 shares of common stock in the name of others **Malcolm S Mackay** Director $1 100 expenses 2 000 shares of common stock **Clyde M Morgan** Director $1 645 expenses 700 shares of common stock **Alonzo Petteys** Director $1 298 expenses 10 000 shares of common stock, 5 011 shares of 5¼% preferred stock **C Frank Reavie** Director $1 001 expenses 4100 shares of common stock 1 157 shares of 5¼% preferred stock **Albert G Redpath** Director $1 312 expenses 1 000 shares of common stock **William Stern** Director $9 600 bonus and indirect compensation $1 733 expenses 1 000 shares of common stock 500 shares of 5¼% preferred stock **Lyman E Wakefield Jr** Director $1 100 expenses 1 000 shares of common stock **Albert J Weatherhead Jr** Director $1 247 expenses 751 shares of common stock

Pan American World Airways Inc—**J T Trippe** President, Director $100 000 salary $—150 bonus and indirect compensation $6 834 expenses 40 730 shares of common stock in the name of others **Roger Lewis** Executive Vice President-Administration Director (terms expired 1/1/63) $5 018 salary $8 200 bonus and indirect compensation $1 421 expenses 3 750 shares of common stock **H E Gray** Executive Vice President OD Director $58 000 salary $41 100 bonus and indirect compensation $5 002 expenses 14 382 shares of common stock $37 800 debentures **W G Lipscomb** Vice President Traffic and Sales Director $46 000 salary $20 100 bonus and indirect compensation $8 044 expenses 15 488 shares of common stock **W L Morrison**, Executive Vice President LAD Director $50 000 salary $24 300 bonus and indirect compensation $7 102 expenses 10 312 shares of common stock **F Gledhill** Vice President Director $44 000 salary $27 300 bonus and indirect compensation $6 601 expenses 8 903 shares of common stock $10 000 debentures **J C Leslie** Vice President and Assistant to the President, Director $44 000 salary $23 000 bonus and indirect compensation $3 003 expenses 7 015 shares of common stock in the name of others **H A Schneider**, Vice President and General Counsel Director $44 000 salary $16 800 bonus and indirect compensation $7 004 expenses 400 shares of common stock **S F Pryor** Vice President Director $35 000 salary, $17 550 bonus and indirect compensation $13 348 expenses 10 000 shares of common stock **J R Gales**, Vice President-Development $42 000 salary $10 000 bonus and indirect compensation $2 410 expenses 2 000 shares of common stock, **E O Ferguson** Treasurer $33 000 salary $18 000 bonus and indirect compensation $3 252 expenses, 4 000 shares of common stock **J C Pirie** Vice President and Associate General Counsel $38 000 salary $12 000 bonus and indirect compensation $1 205 expenses 4 135 shares of common stock **J S Woolbridge**, Comptroller $33 000 salary $15 000 bonus and indirect compensation $1 145 expenses 1 750 shares of common stock **A P Adams**, Vice President $34 000 salary $12 000 bonus and indirect compensation $4 087 expenses 2 550 shares of common stock $100 debentures **H B Adams** Vice President, $34 000 salary $12 000 bonus and indirect compensation $6 711 expenses 6 040 shares of common stock **R B Murray Jr** Vice President, $35 000 salary $11 000 bonus and indirect compensation $11 952 expenses 1 500 shares of common stock **R S Mitchell**, Vice President CMRD $37 000 salary $12,000 bonus and indirect compensation $8 215 expenses 4 047 shares of common stock **H D Berke** Vice President $31 000 salary $12 000 bonus and indirect compensation $2 280 expenses 2 276 shares of common stock **E Balluder**, Vice President $32 000 salary $3 000 bonus and indirect compensation $7 901 expenses, 13 475 shares of common stock 4 850 shares of common stock in the name of others **S E Smith** Vice President $35 000 salary $5 000 bonus and indirect compensation $10 325 expenses 52 shares of common stock $400 debentures **E M Goulard** Vice President-Industrial Relations $26 000 salary $3 000 bonus and indirect compensation $5 018 expenses 1 000 shares of common stock **L S Kuter** Vice President, (entered office 10/1/62) $8 000 salary $1 300 expenses 100 shares of common stock **N F Blake** Vice President $23 000 salary $5 000 bonus and indirect compensation $8 715 expenses 2 023 shares of common stock **J A Montgomery**, Vice President-Passenger Sales (entered office 12/4/62) $1 510 salary $2 500 bonus and indirect compensation $43 expenses 211 shares of common stock $400 debentures **A J Kelly** Vice President $23 450 salary $5 000 bonus and indirect compensation $3 985 expenses 2 158 shares of common stock **H M Blackwell** Vice President SOS $21 000 salary $4 000 bonus and indirect compensation $1 221 expenses 700 shares of common stock **H L Graham Jr.**, Vice President Cargo Sales (entered office 12/4/62) $1 881 salary $130 expenses 100 shares of common stock **J Macy Jr**, Secretary $17 000 salary $2 000 bonus and indirect compensation $239 expenses **W W Lynch** Assistant Vice President-Comm $34 337 salary $6 000 bonus and indirect compensation $11 812 expenses 2 887 shares of common stock $16 300 debentures **S R Kauffman**, Assistant Vice President Engineering $24 000 salary $8 000 bonus and indirect compensation $1 360 expenses 1 500 shares of common stock **E Dressler** Assistant Comptroller $25 000 salary $6 000 bonus and indirect compensation $1 913 expenses 1 003 shares of common stock **R P Monson** Assistant Treasurer $21 000 salary $9 000 bonus and indirect compensation $1 628 expenses 1 670 shares of common stock **J E McGuire** Assistant Vice President $23 000 salary $5 000 bonus and indirect compensation $5 673 expenses 243 shares of common stock **R S Hogerland** Assistant Vice President Industrial Relations, $21 000 salary $4 000 bonus and indirect compensation $1 228 expenses 200 shares of common stock **D W Thomson** Assistant Comptroller (entered office 12/1/62) $1 667 salary $2 000 bonus and indirect compensation $120 expenses **C W Moore**, Assistant Vice President-Traffic and Sales Administration $18 000 salary $1 500 bonus and indirect compensation $1 377 expenses







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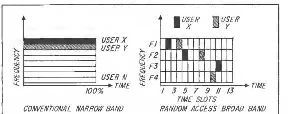
Industry's Reliability Standards Criticized

Washington—Industry managers, foremen and production workers think their reliability standards are higher than they actually are, according to Walter L. Lingle, Jr., deputy associate administrator, NASA.

Lingle said it is difficult to convince industry management that its reliability standards are not high enough for NASA, which has the overriding objective of high reliability and systems performance. Once management understands the reliability requirement, he said, there is another "tremendous problem" in re-training the work force to a higher standard.

Speaking before the American Institute of Aeronautics and Astronautics here, Lingle said "one of the most important elements of technological spin-off that can accrue to American industry from the space program is a capability to produce a higher degree of reliability when it is demanded."

He said that the space program has produced about 1,000 innovations so far and the greatest percentage have been in processes and techniques rather than in new products. The agency is attempting to develop a system to disseminate data on these innovations, which may be in the form of a catalog or a newsletter, Lingle said.



NEW RANDOM ACCESS DISCRETE ADDRESS radio communications technique departs sharply from historic procedure of dividing up radio frequency spectrum into narrow band channels which are assigned to individual users (left). In new technique (right), large group of users share a broad band of channels, transmitting voice by means of series of pulses each of which is transmitted at a different sub-channel frequency and different time, permitting simultaneous conversations.

System Offers Private-Line Radio Service

By Philip J. Klass

Washington—Random access discrete address, enables multiple users each to enjoy "private hot-line" service comparable to today's telephone in contrast to "party line" service of conventional radio. The technique is arousing growing interest for military and space applications.

Random access discrete address system (RADA) is being considered by the Defense Communications Agency for use in a military communication satellite system where many widely scattered points seek simultaneous use of the system. National Aeronautics and Space Administration's Goddard Space Flight Center recently invited 20 companies to submit proposals for a study of multiple-user access to a communication satellite system. RADA will be one of the techniques considered.

Under three recently awarded Army contracts, each for $2 million, Martin Orlando, Motorola and Radio Corp. of America are conducting one-year RADA program definition studies. Out of this program the Army hopes to select an optimum RADA technique for battlefield use to provide its infantry with the radio equivalent of private-line telephone service.

Martin-Orlando has proposed use of the random-access discrete address technique to the Federal Aviation Agency for terminal area ground-to-air communications. This is planned to simplify and expedite pilot contacts with the ground controllers sequentially involved in approach, landing, takeoff and departure. The technique also is being considered for use in a military airborne communications relay station for counter-insurgency type situations or for emergency command and control functions.

Random access discrete address communications violates the standard practice of attempting to accommodate users by squeezing the channel bandwidth of each into a smaller piece of the radio frequency spectrum.

RADA requires the use of relatively large spectrum assignments, usually measured in megacycles instead of the conventional kilocycles. But for some applications, the new technique offers more efficient use of the spectrum than conventional practices that are currently used.

While Martin-Orlando was one of the first companies to demonstrate a feasibility model of a RADA-type equipment two years ago (AW June 19, 1961, p. 87) and has applied for a number of patents in the field, prior work was done by Bell Telephone Labs.

RADA technique appears most applicable for a situation where there are many geographically dispersed mobile users, any one of which may, at any time, need to communicate with any other user. This situation corresponds to that of a group of telephone subscribers. RADA does not appear advantageous for trunk-line service between only two terminals.

In conventional radio communications, the spectrum normally is sliced into channels with one (or more) assigned exclusively to each user, or a group of users. Although a bandwidth of 6 kc. is sufficient to handle voice communications, the spectrum assigned for each channel must be several times this value to prevent interference between channels due to instability or design limitations in the transmitter/receiver. For example, in civil air-ground communications, a total of 50 kc. is reserved for each voice channel.

If each user employed his assigned channel full time, the present system of narrow-band communication channels would not waste too much of the spectrum. But in some situations, such as

Random Access Acronyms

Variety of acronyms have been developed by different companies and agencies to name their random access discrete address systems, including:

- RADA (Army): Random Access Discrete Address
- RACEP (Martin): Random Access and Correlation for Extended Performance
- RADEM (Motorola): Random Access Delta Modulation
- CAPRI (Bendix): Coded Address Private Radio Intercom

an army operating on the battlefield, any one user may need a channel only for a small fraction of the total time—yet when needed, the user wants immediate access to another party without delay. With conventional techniques, he may find the assigned channel or "party line" in use by others

An inherent advantage of the RADA technique is that it can provide a large number of users with instant access to any other user within range, unless he already is talking to a third user. RADA appears able to handle many more conversations than conventional techniques, unless the latter employs elaborate provisions for frequency reassignment and or switching

With RADA, a relatively wideband channel is assigned to a large group of users, the precise figure depending upon the number of users within communications range and the modulation technique employed. The voice modulation is converted into digital format (pulses), and the pulses are transmitted in sequence, each at a different carrier frequency within the assigned wideband channel and at a different assigned instant in time, called time-slots

For example, as shown in the sketch (p. 115), if User X wants to talk with User A, the former would transmit his first pulse at frequency F1 during time slot 2, the second pulse at frequency F2 during time slot 5 and the third pulse at F3 during time slot 11. Simultaneously, another conversation involving User Y and User B would be conducted, with transmitter Y sending its first pulse on F1 during time slot 4, its second pulse at F2 during time slot 8 and its third pulse at F4 during time slot 10. Communication from User A to User X, and from User B to User Y, would be transmitted at two different combinations of frequencies and time pulses

Each receiver has an exclusive combination of frequencies and time-slots, equivalent to a telephone number, to which it has been set to respond. In theory, only those pulses which arrive at its assigned combination of frequency and time slot are converted into audio for the user

To call any particular user within range, an operator would look up his time-frequency address in a directory, set this into his own transmitter and push a call button. This would flash a light or alarm only in the equipment being called. When the party called picks up his handset, the two users are in direct communication—just as if one telephone user has dialed another

Under normal conditions neither party will be aware that other users within range and simultaneously carrying on conversations in the same broadband channel. Should the number of users talking simultaneously increase appreciably, all users will begin to hear increased background noise in the form of faint clicks. These are caused by messages intended for another receiver in which an occasional pulse happens to

MOTOROLA'S random access delta modulation (RADEM) feasibility model has three small dials used to select "address" of party being called. Only the called party can hear the voice transmission.

have the right combination of frequency and time-slot to penetrate

RADA has an inherent ability to ease overload conditions If the number of users talking simultaneously greatly exceeds design limits, the background becomes increasingly noisy for all users within range This tends to discourage users carrying on lower-priority conversations prompting them to hang up, which in turn reduces the overload background noise for higher-priority users

The number of different sub-channel frequencies required, and therefore the total bandwidth per RADA channel depends in part upon the maximum number of users which the system must accommodate in simultaneous conversations and the acceptable level of degradation in service during such conditions

In early feasibility models, which Martin-Orlando constructed for evaluation by the Army, Rome Air Development Center and USAF's Electronic Systems Div., the equipment used 16 time slots and three different 100-kc sub-channels providing a system with up to 720 different user addresses

A RADA system suitable for an Army division probably would require several thousand individual units of equipment and a corresponding number of discrete addresses These would be obtained by using additional bandwidth to provide more sub-channel frequencies

One of the objectives of the Army RADA programs with Martin, Motorola and RCA, is to study different design techniques and determine which are best for field army use Following completion of these contracts next spring, one of the three companies will be selected to develop prototype hardware for field evaluation If RADA lives up to its proponent's claims, it appears likely that the Army will authorize production

Martin and Motorola apparently will use the frequency-time matrix technique described earlier The major difference in their approaches will be the digital format used to convert voice modulation into pulses suitable for RADA In early models, Martin used pulse-position modulation while Motorola adopted delta modulation

Motorola's H W Grossman, deputy program director for RADA says however, that the company plans to investigate more than a dozen different modulation techniques in the course of its Army study, including delta pulse-frequency and pseudo noise modulation

In the Motorola feasibility models, the amplitude of the waveform of the voice modulation is measured 38,400 times per second and converted by delta modulation into a string of pulses or no pulses which are a measure of the voice waveform amplitude at the instant sampled Each pulse or no-pulse vacancy is 26 microseconds in duration (See sketch in col 1)

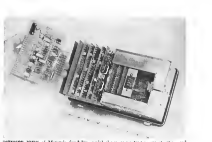
Each of these individual 26-microsecond pulses is then used to generate a series of short pulses of ½-microsecond duration having the appropriate frequency/time-slot address of the party to whom the message is being sent

It is these sub-pulses which are transmitted, not the 26 microsecond delta modulation pulses For example, in the sketch shown below left, the first ½ microsecond pulse is transmitted at frequency F1 in time-slot 1, while the second pulse is transmitted at frequency F4 in time-slot 4 and the third pulse goes out on frequency F2 in time slot 9

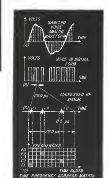
Receivers of all users within range will receive these short pulses, but the particular combination of frequencies and time slots will actuate the logic circuitry only of the receiver to which the message is addressed This receiver responds by recreating the original delta modulation, which in turn is used to reconstruct the voice waveform

As the number of simultaneous communications builds the timing and frequencies of pulses arriving from several nearby transmitters may combine by coincidence to match the frequency-time matrix of a receiver other than that of the intended user This will produce very brief blips of noise in the unintended receiver but will not enable the latter to eavesdrop on the other

Motorola selected delta modulation for its feasibility models and for equipment supplied to an unidentified customer, because it offers high quality voice reproduction and uses extremely simple circuitry to accomplish modulation and demodulation compared with



INTERIOR VIEW of Motorola feasibility model shows computer-type construction and reveals absence of usual tuning and frequency synthesizer complexity Transmitter and receiver are enclosed in L-shaped containers Remainder of unit contains digital logic and modulation/demodulation circuitry



RADEM PRINCIPLE of operation, similar to technique used by Martin-Orlando, is shown above Voice waveform (A) is sampled 38,400 times per second, converted into series of pulses or no-pulses by delta modulation (B) Each 26 microsecond pulse then is broken down into series of ½ microsecond pulses (C) each of which is transmitted at frequency and in time slot corresponding to address of intended receiver (D)

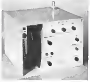
other types of pulse code modulation, according to Henry Magnuski, associate director of research for company's Military Electronics Div., Chicago. Motorola program manager for the Army study is Walter P. Czeropski, Jr.

Delta modulator requires only a few transistors on a single printed-circuit card and a delta demodulation consists only of a one-resistor, one-capacitor integrator and an audio amplifier, with a low pass filter being optional, Magnuski says. No synchronization is required for use of delta modulation and it has relatively low quantizing noise, he adds.

Pulse-Position Modulation

The pulse-position modulation (PPM) used in Martin's early feasibility models requires fewer pulses than delta modulation to define the voice waveform. Grossman says that this offers the advantage of creating fewer pulses in a high-density communications area with a resultant reduction in background noise when there are many simultaneous conversations. It permits the use of narrower subchannels with resultant savings in bandwith. However, Grossman emphasizes that Martin is not committed to PPM for its Army study program.

RCA says its interest in RADA dates back to the early 1950s. It has investigated a number of different technical approaches involving both pulse and continuous-carrier transmission with various address codes including time frequency matrixing. Modulation techniques investigated include pulse position, pulse code delta frequency modulation, single sideband and others the company says.



MARTIN was first company to publicly demonstrate random access discrete address communications two years ago using this feasibility model.

An important byproduct advantage of RADA is expected to be improved reliability and lower-cost equipment according to Motorola's Magnuski. Because the subchannel bandwith is much wider than conventional radio equipment, 2 mc. vs. 50 kc., it will be possible to use less complex frequency references. A drift of 100 kc. in a RADA unit would be within tolerable limits. In a conventional radio equipment it would be completely unacceptable, Magnuski says.

Major item of cost in any conventional radio equipment is the frequency synthesizer to provide the hundreds or thousands of selectable narrow-band channels and the associated mechanical tuning drives for frequency selection. These costly and often unreliable elements are not needed in RADA equipment, Magnuski points out.

Microcircuit Use

Because a large portion of a RADA unit involves pulse/digital operations, the new technique is particularly well suited to the use of semiconductor microcircuits. This also should be a source of improved reliability and, eventually, should result in lower-cost equipment.

In the current Army RADA program definition phase, Motorola is teamed with International Business Machines Corp. and Armour Research Foundation. IBM is conducting battlefield communication simulation studies, while ARF is studying the problem of electronic countermeasures. Martin

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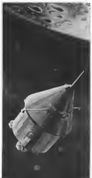

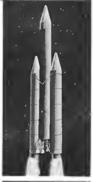

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To design transistor feedback, servo amplifier and low level switching circuits. BS or MS with three or more years experience in the above fields desirable.

SENIOR MATHEMATICAL ANALYST

To engage in mathematical and computer studies relating to the evaluation and optimization of new and improved inertial instruments, components and systems. BS or MS in applied mathematics or physics, plus three to five years experience in mathematical and/or computer analysis.

MECHANICAL ENGINEER

To design miniature inertial platforms and gimbal systems. BSME required, plus three to five years experience in the inertial platform-gimbal systems field.

MATHEMATICAL ANALYSTS

To perform analysis as required in the development of inertial components and systems. BS or MS in applied mathematics plus one to three years experience in the field of mathematical analysis.

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Orlando has awarded study subcontracts to Adcom, Inc., Cambridge, Mass. and Jansky & Bailey, Washington.

The latter company is conducting frequency/cost tradeoff studies for the program.

Judging from the list of bidders for the recent Army RADA contract, a number of companies besides Martin, Motorola and RCA are active in the new technique.

Other Bidders

Other bidders included Bendix, Hughes Aircraft Co., International Telephone & Telegraph Corp., Raytheon and Sylvania.

For security reasons, companies are reluctant to discuss the vulnerability of RADA to enemy jamming, but certain characteristics are apparent.

Because each communication is addressed uniquely to a single receiver, RADA makes it far more difficult for an enemy to eavesdrop on radio conversations than with conventional equipment.

Because RADA is a broadband system, it requires considerably more powerful and more sophisticated equipment to jam it than conventional narrow-band radio channels.

VAX Avionics

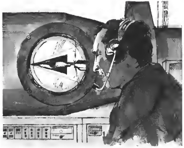
Defense Dept's philosophy for design of equipment to be used in contemplated VAX aircraft seems to avoid unnecessary duplication of components and subsystems, such as gyros, computers and radars, by means of a concept known as "integrated avionics"—not to be confused with the term "integrated circuits," which is sometimes applied to microcircuits.

Describing the approach which DOD intends to use, deputy director of defense research and engineering for tactical warfare programs Dr. John H. McLucas said the VAX mission will first be spelled out in terms of what kind of information the pilot and/or observer needs.

Working backward from this, the kinds of sensors required to obtain the basic data and the types of computation and display will be established, McLucas said.

System contractor selected for the VAX integrated avionics must specify over-all system logic and interfaces between subsystems so that all data that is obtained is usable by a central data processor.

McLucas speculated that the job might be a logical one for a computer company, but said the system contractor also must use available hardware as well as technology from other industry suppliers.



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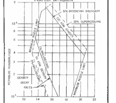

Mach No	14 to 21
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Angle of Attack	−10° to 190°

Demonstrated Testing
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- b Local pressure
- c Dynamic stability
- d Local Heat transfer
- e Rocket exhaust efforts on vehicle stability

WHO'S WHERE

(Continued from page 23)

Changes

Robert N. Buland, manager, Flight Control Electronic Systems, Mobile Mid Range Ballistic Missile Program (MMRBM), San Bernardino (Calif.) Operations, Aerospace Corp., and **Solomon H. Turkel**, assistant manager, Weapons Systems Analysis, MMRBM. Also: **Thor A. Bergstralh**, head of the newly established Weapons Effects Dept. of the San Bernardino Operations; **Max R. Grandvig**, section head, Information Processing Section, Computation and Mathematics Center, Technical Div., San Bernardino.

Raymond C. Harbert, director, Customer Service, General Dynamics/Astronautics, San Diego, Calif.

Frank Cov, manager, Field Support Dept., Westinghouse Electric Corp.'s Defense Center operations, Baltimore, Md.

Dr. Irving Statler, head, Applied Mechanics Dept., Cornell Aeronautical Laboratory, Buffalo, N. Y., and **Richard P. White, Jr.**, assistant head.

L. Robert Jessen, administrative assistant to the vice president for marketing, Beech Aircraft Corp., Wichita, Kan.

H. Brainard Fancher, general manager, General Electric Co.'s Apollo Support Dept., Daytona Beach, Fla.

Frank A. Stocks, manager-charter sales, Trans World Airlines, Inc. Also: **Louis S. Uht**, manager-marketing budgets; **George E. Roe**, manager-marketing performance analysis; **Burke E. Smith**, manager-marketing services.

Rudi Beichel, manager of the newly established Research and Advanced Technology Div. of the Liquid Rocket Plant, Aerojet-General Corp., Sacramento, Calif., and **Dr. Clair Beighley**, assistant manager. Also: **Herman L. Coplen, Jr.**, senior manager, Engineering Div. of the Liquid Rocket Plant.

M. R. Ramos, marketing manager, Cramer Div. of Giannini Controls Corp., Duarte, Calif.

T. R. Hensley, manager-facilities, Solid Rocket Div. of Rocketdyne, a division of North American Aviation, Inc., McGregor, Tex.

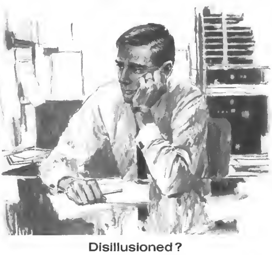
Dr. James A. Marsh, associate group director, Space Launching Systems Development Group Titan 3 Standard Space Launch System, Aerospace Corp., Los Angeles, Calif., and **Barnhard A. Hohmann**, systems engineering director of the new NASA Manned Launch Vehicle Programs Office (Mercury and Gemini launch vehicles).

Dr. Diane Ramsey has joined Astropower, Inc., Newport Beach, Calif., as a senior scientist in the Research Div.'s electronic laboratory.

Bruce Knudson, special projects engineer, advanced programs, Canoga Electronics Corp., Van Nuys, Calif.

Edwin M. Lindsay, manager, Aerospace Research Laboratory, Owens-Corning Fiberglas Technical Center, Granville, Ohio, and **Herbert B. Ades**, assistant to the director of research.

Glenn Ewald, in charge of marketing and sales, Aerospace Products Div., Swedlow, Inc., Los Angeles, Calif.



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FOR NEW ASTRO SCIENCES CENTER

of Armour Research Foundation

The Armour Research Foundation opened its new Astro Sciences Center in April. This activity, devoted exclusively to the nation's current and long range space programs, will be concerned with developing new approaches to technical problems of large, complex space missions.

The staff of the center will draw from the extensive resources of the entire Foundation which include such advanced working tools as an IBM 7090 and a Univac 1105. A challenging ground floor opportunity to join this staff is available for a man with an advanced degree in Astrophysics, Physics or Astronomy and 3 to 5 years experience in broad areas of astrophysics. Address your inquiry to Mr. Ray C. Sepp.

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of Illinois Institute of Technology
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The name Armour Research Foundation will be changed to I I T Research Institute effective June 1, 1963

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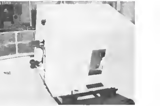

ENGINEERS & SCIENTISTS

At Grumman, many advanced laboratories and test facilities enable our engineers and scientists to subject new theories and designs immediately to comprehensive experimental verification. Shown above, Bruce Kiesler, Structural Test Engineer (joined Grumman in '59), Dr. Joseph Lisa, Physiologist (joined Grumman in Mar. '63), Kenneth Lee, Supervisor of Structural & Environmental Test Lab (joined Grumman '34), Joseph Szymanski, Lead Man—Environmental Test Lab (joined Grumman '51), and Bill Wenzel, Physicist (joined Grumman in '58), are responsible for the construction and the operation of Space Station Simulations.

This is but a small part of the up-to-the-minute equipments currently available at Grumman. To engineers and scientists who are hamstrung by inadequate facilities and who recognize that their full potential can only be realized when they are given the tools to do the job, Grumman offers a new horizon for professional advancement. Those seeking such an empirical environment will find responsible positions immediately available on advanced space programs.

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Weight Optimization Engineers—To originate and contribute to the development of practical minimum weight design to conduct trade off studies for vehicle optimization and to carry out weight control during design of aerospace structures and systems. BS and 5 years aerospace experience within your specialty and general engineering competence are required.

Mechanical Design Engineers—BS in ME, CE or AE with a minimum of 5 years experience in mechanical systems design, preferably familiar with aerospace design practices. Background should cover one or more of the following areas: mechanical linkages and their motions analysis, structural design of mechanical components, determination of power requirements and selecting of power supply, shock attenuation devices, wheels, brakes, anti-skid and steering devices and interpretation of military specifications. Duties: Assist in the formation of Aerospace Alighting Gear System concept and in the detail design of the overall system and its components. Also establish the Lunar Landing System configuration and participate in the design of the system, design for stowage, extension and erection of the system in space and lunar environment, establish test requirements for the system in space and lunar environment, study and establish landing energy absorption requirements and medium compatible with space and lunar environment.

Aerospace Environmental Control & Life Support Systems Engineers—BS in ME, Chemical Eng. or EE with a minimum of 2 years fluid mechanics and/or thermodynamics experience in analysis, design, development, testing, installation for aircraft and space vehicles in one or more of the following areas: ENVIRONMENTAL CONTROL (Cabin Equipment, Pressure Suit cooling, heating, pressure, humidity controls); LIFE SUPPORT (Stored, Regenerative, Ecological Systems, CO_2, toxic gases, odor and moisture removal); CRYOGENICS (Storage, Supply, Temperature and Pressure Controls); TESTING (Development, Qualification, Functional, Preflight).

Fluid Mechanics Engineers/Internal Aerodynamicists—BS or MS with a minimum of 2 years experience and applicable to analyses and test work on Reaction Jet Control Systems, Nozzle Design, Inlets, Jet Exhausts, Gas Bearings, Pressurization Systems, Thrust Vector Control, VTOL Internal Flow and Airborne Cooling Systems.

Propulsion Aerodynamicists/Aerothermodynamicists—BS or MS with 2 years minimum experience in one or more of the following: Nozzles, Thrust Vector Control, Air Induction Systems, Reaction Jet Systems, Ducted Fans, Rocket Plumes, Pressurization Systems, Airborne Cooling, Boundary Layer Analysis and Control, Rotary Machinery Analysis, Ramjets, Exhaust Systems, Compressible Fluid Flow, Windtunnel Testing, Thrust Reversers and Hypersonic Airbreathing Propulsion Systems.

Temperature Control Engineers—BS or MS and 2 years experience to handle space vehicle temperature control system analyses. Should have background in radiative heat exchange and thermal coatings as applied to passive and active temperature control systems.

To arrange a mutually convenient interview, send your resume to Mr. H. A. Kline, Technical Staff Engineer, Dept. 25

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AVIATION WEEK, MAY 13, 1963

AERO-THERMODYNAMICS

North American Aviation's Space and Information Systems Division recognizes the role of research and its importance to the successful development and synthesis of manned and unmanned space vehicles of the future.

The Aero-Thermodynamics Department is an applied research division of S&ID and is engaged in advanced state-of-the-art studies associated with many interesting aerospace studies and concepts.

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Direct inquiries in confidence to:
Mr. A. E. McKenzie, Engineering and Scientific Employment, Dept. 020, 12214 Lakewood Blvd., Downey, California

All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin.

SPACE AND INFORMATION SYSTEMS DIVISION
North American Aviation

Crash Beacon

Re Crash Locator Beacon

We were interested to read Wallace L. Brown's letter (AW Apr 29, p 110) concerning a crash locator beacon, and concur with his sentiments about the need for such a device. The idea of a crash survivable beacon that sends out a locating signal to searching aircraft has been studied extensively in both the U S and Canada Mechanical designs have been worked out that will assure operation whether the crash is on land or sea They are simple and would not be an item of major expense to the using commercial airline, military or private operator

Perhaps a reason they have never been fully developed and placed in service is the relatively short radius of coverage For example the line of sight limitation for a search plane operating at 40 000 ft is about 250 mi and this would be severely degraded by turbulent seas

For complete coverage of the earth, satellites provide an effective answer One system for locating disabled planes ships and space craft with satellites has been dubbed LOCHINVAR—not an acronym but the name of a fictional knight of old (thanks to Sir Walter Scott) who we thought achieved distinction for rescuing the maid Ellen in distress (It turns out they eloped) With this system, several satellites continuously monitor certain distress frequencies Data received by a satellite which is sufficient to locate the distress beacon to within a few miles, is reported to one of several ground rescue stations The number of satellites depends upon re tion time required For example four s tes at 500 mi altitude would result in an av age reaction time of about an hour

The cost per using aircraft for the beacon package would be small The cost of the satellite and ground station equipment, while high compared to traditional survival gear, could be shared to some extent with other satellite payloads Being a world wide service like weather satellites, such a system could prove to be another very useful medium for international cooperation and good will

Calvin R Woods
George H Weber
General Electric Co
Defense Electronics Div
Radio Guidance Operation
Syracuse N Y

Slayton Problem

In re the box on p 61 in the April 15th issue astronaut Slayton fortunately does not have ventricular fibrillation—a major disturbance of cardiac rhythm which is fatal in a high percentage of cases The instrument described is, I am sure, intended for the treatment of ventricular fibrillation, but will be used only in operating rooms, emergency rooms and other hospital units where the arrhythmia can be diagnosed promptly and treated

The Slayton problem is one of auricular

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fibrillation—at least it is my recollection that such is the case Per se auricular fibrillation is compatible with continual existence for years, and in the so called paroxysmal state (which may be unassociated with demonstrable cardiac disease) it may be only a "nuisance," albeit a nuisance which may not be considered desirable in orbit

R J Glaser M D
Denver Colo

(Dr Glaser is correct Astronaut Donald K Slayton suffered from atrial fibrillation, which occurs in the upper or valve part of the heart Ventricular fibrillation occurs in the lower part—the pumping mechanism—of the heart —Ed)

Spray vs. Pour

We would like to comment on your article entitled "Minuteman Carrier Insulation Sprayed" (AW Apr 1, p 94) which was generally factual and well written

You neglected to give due credit to Boeing Engineering, who originated the idea of spray form insulation for the Minuteman transporter-erector

The first application of spray foam to the carrier was made by Boeing at Seattle In an attempt to eliminate the cost of interior trimming Cessna experimented with the "pour foam method as described in your story

The main objection to the "pour foam" method was excessive weight which resulted from large areas of high density foam The spray application method provides a consistent low density material with high insulation value

Wm Moore
Chief Project Engineer
Military Division
Cessna Aircraft Co
Wichita Kan

Capacity Rejoinder

Mr Curtis Olsen of PAA by his letter to Aviation Week (Jan 21 p 136) appears to have either misread or misunderstood my letter (AW Nov 26 p 118) We don't hold as alleged that the cure for world wide excess capacity is its multiplication but that the crux is underfill which will only be aggravated by restriction upon counter restriction

Before dealing with the remainder let me first dispel Olsen's confusion respecting any "strange" contrasts between the pilots of Seaboard World and our employer by redirecting his attention to this committee's sole sponsors clearly named in the asterisked note below my last letter and this

The stated needs of the CAB's staff members set forth in his referenced testimony of CAB Bureau witnesses in the Foreign Air Carrier Investigation Docket 12063 have apparently been disposed of indeed better than I could by the CAB (see AW Feb 11, p 38) The Board has clearly reaffirmed our historic position, in consonance with that stated by me, contra any and all forms of cartelizing; and incidentally, our experience in this field—and this may come as a surprise to Capt Olsen—started the first day we went to a grade school history class many years before his Route Structures Committee was even imagined

The history of Britain's position is too lengthy to go into here in detail Suffice it to say that while she was originally apprehensive in her view of the U S multilateral or "open skies" approach she by no means intended the restrictive clauses of the bilateral compromise to go as far as advocated by Olsen and other segments of the industry and government It was widely and reliably reported in the press that during the U S U K bilateral talks in the spring of 1960 Mrs Alison Munro of the British Ministry of Aviation so informed the U S delegation in no uncertain terms

No progress can be made in any exchange of views by the practice of rejecting as inaccurate or insufficient any figures that do not suit us as Olsen does mine on U S South America traffic They are the only figures available were gleaned from the same Docket 12063 that Olsen so frequently quotes in his own behalf and must certainly be more accurate than Curt's apparently psychic suspicion to the contrary I repeat the chances are more than good that Pan Am pilots will lose on this exchange otherwise why has PAA management so vigorously protested any capacity controls whatsoever in this theater of operations?

Any difficulty in imagining how the Common Market might unilaterally denounce bilaterals is easily resolved merely add the terminals PAA and TWA serve in the six nations subtract the number their airlines serve in the U S., and the difference is the number of terminals we'd lose in the Air Union block Then delete all terminals within the six where PAA/TWA can pick up at one and discharge at another for unless Air Union could do the same between all their combined points in the U S (and our domestic carriers can easily be seen dropping Pan Am's banner like a hot rivet at this point) they certainly aren't going to condone it in their own bailiwick

Finally our congratulations to FAA pilots for changing their committee's charge for "the purpose of publicizing conditions that have stultified growth of their employer and generally produced stagnancy in U S flag carrier operations" to the more positive "effort to resolve the problems facing the industry while encouraging growth and development of flag air carriage" They have thus taken their first timorous step in our direction

Floyd S Benjamin Chairman
Committee on Legislation*
Seaboard World Pilots

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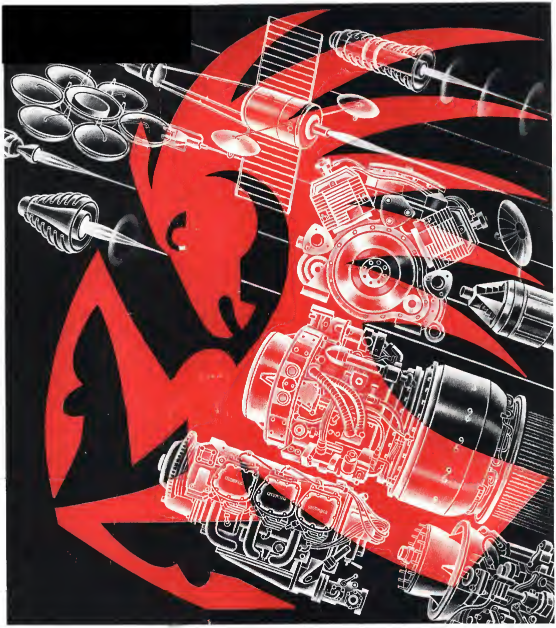

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